The Papua and New Guinea Agricultural Journal

Vol. 9 July, 1954 No. 1

Department of Agriculture, Stock and Fisheries,
Port Moresby

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COMMONWEALTH OF AUSTRALIA

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The

Papua and New Guinea

Agricultural Journal

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Volume 4, Numbers 1, 2, 3 and 4.
Volume 5, Numbers 1, 2 and 3.
Volume 6, Numbers 1, 2 and 3.
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The Papua and New Guinea Agricultural Gazette—

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Copies of all numbers of the *Gazette* to Volume 7, No. 4, are out of print.

The Papua and New Guinea
Agricultural Journal

Vol. 9 July, 1954 No. 1

COFFEE CULTIVATION IN PAPUA AND NEW GUINEA

R. E. P. DWYER, B.Sc. (AGR.), H.D.A., H.D.D.*

Introductory Article.

(This article is the first of a series dealing with coffee growing in Papua and New Guinea.)

THIS short introduction on coffee cultivation in Papua and New Guinea is intended to meet, as far as possible, the immediate needs of Territory producers engaged in this important plantation industry.

All phases of coffee cultivation and production cannot be dealt with adequately in an article of this type. It is thus intended that this brief guide should precede a series of detailed articles, each of which will deal with one specific aspect of the subject in greater detail. These separate articles will later be combined to make a complete handbook on the cultivation, processing and marketing of coffee, with special reference to Territory conditions. Some of the important topics to be discussed are :—

1. Soil and climatic requirements.
2. High and medium altitude production.
3. Low altitude production.
4. Cultivation and clearing problems.
5. Nurseries, cover crops, temporary and permanent shade and planting technique.
6. Coffee varieties.
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The Botany of the Coffee Plant.

All the species of coffee belong to the order *Rubiales* and the family *Rubiaceae.* There are two main subdivisions of the *Rubiaceae*; *Cinchona* is the type plant of one group and *Coffea* is the type representing the other main subdivision, the *Coffeeoideae.* Several species in the *Coffeeoideae* are of commercial importance, particularly *Coffea arabica* L. (Arabian or Arabica coffee), *C. robusta L.* (Robusta coffee) ; *C. liberica* Bull (Schum.) (Liberian coffee) ; *C. stenophylla* G. Don.

All these species occur in the Territory as well as a number of others of minor importance and many hybrids.

The Robusta and Liberica types grow into shrubby trees up to twentv feet or thirty feet high if left unpruned. They are both considered to be low altitude species. Liberica has very large fruits which are of poor quality whereas the smaller Robusta beans are the main bulk coffee of commerce. Arabica is usually grown at higher altitudes and is somewhat smaller and less vigorous than Robusta; the leaves of the former are also more pointed and the fruits generally larger than those of the latter. *C. stenophylla* is a brown-fruited tvpe producing small, high-quality beans.

There are a few trees of *C. stenophylla* at Popondetta and *C. liberica* can be seen in New Britain, but neither is of commercial importance in this Territory. Only varieties of *C. robusta* and *C. arabica* and possibly some hybrids are likely to be widely grown here. Robusta is of lower quality than Arabica but is generally considered to be a higher yielder although it has a lower ratio of bean to pulp (1 to 7) than the latter (1 to 5 or 1 to 6).

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A full botanical description of the coffee plant will not be given here as adequate literature on the subject is available. It should be mentioned, however, that coffee has white, tubular, hermaphrodite flowers borne in clusters at the nodes on new lateral wood only, which is of importance in pruning. Pollination may be effected by wind or insects but many types are said to be self-compatible and normally self-pollinated. Varieties vary in this respect but cross-pollination is usually essential for the maximum production by *C. robusta.*

The fruit is a two-seeded drupe resembling a cherry, with one seed in each locus. The sweet pulp is removed by a combination of mechanical and fermentative processes, and the hard parchment and underlying silverskin are also removed mechanically to give the coffee bean of commerce.

Most members of the *Rubiaceae* are noted for their drug secreting properties. The well-known stimulant "caffeine" is the main alkaloid in coffee and it can be extracted from waste whole and broken beans. Other alkaloids are present in lesser quantities.

The History of Coffee Growing in the Territory.

Both Arabica and Robusta coffee have been grown on a relatively small scale in the Territory for the past 50 years. However, prior to the 1939-1945 War, most interest was shown in Robusta coffee grown from sea-level to about 1,500 feet elevation.

Several European plantations of Robusta coffee of up to 500 or 600 acres were destroyed during the War and many Native plantings at Sangara were devastated by the Mount Lamington eruption in the post-war period. The rehabilitation of these latter plantings is in progress. Since 1945 there has been little European interest shown in this type of coffee although there is room for expansion in areas where the labour position is not too difficult. Native plantings of lowland coffee are on the increase in some areas, particularly Finschhafen, Samarai, Morobe and Popondetta.

An Arabica coffee plantation was established by the New Guinea Department of Agriculture at Wau in 1928, using the high quality Blue Mountain Jamaican variety of Arabica, which was specially introduced by the Department for this purpose. The original small planting was later purchased privately and expanded to several hundred acres. This area is still in profitable production and a number of smaller plantations have been established in the same District using seed derived from the original plants. A small plot of coffee was also planted at Aiyura in 1937 using seed from the same source.

Since 1945 the main development by both Natives and Europeans has been in the growing of high-quality Arabica coffee at elevations ranging from 1,500 feet to 6,000 feet or more, particularly in the New Guinea Highlands. Expansion in these Districts is proceeding apace, although still in limited areas, and inquiries are received constantly from within the Territory, Australia and overseas regarding the economic prospects of this crop.

The Territory is still free of the devastating coffee rust caused by the fungus *Hemileia vastatrix* and plantings everywhere have thrived with a minimum of disease or insect damage. Rigid quarantine restrictions on the importation of coffee from other countries are designed to prevent the introduction of coffee rust as well as other diseases and insect pests.

Varieties of Coffee.

There are at present no well-defined varieties of Robusta coffee grown in the Territory, and the seed which is available gives rather a variable type of bush. The cross-pollination which is the rule in Robusta makes it difficult to achieve uniformity but the Department is working with improved introduced strains and it is hoped that seed will be available in a few years' time.

Almost all the Arabica coffee grown in the Highlands at present is derived from the seed introduced to Aiyura in 1937. However, several more recent introductions made at Aiyura show promise of approaching or even exceeding Blue Mountain Jamaican in yield or quality. These varieties are undergoing trials prior to a decision on their release to growers.

Plantation Practice.

A brief review only of some of the salient features of plantation practice will be given here. It is recommended that at this stage of development in the Territory, methods

employed on plantations should, as far as practicable, be on orthodox lines. Experimentation should be left until growers are more conversant with the crop.

Coffee is a true horticultural plant and must be treated as such. It requires as much attention as the average fruit tree in a commercial orchard. It is a shade-loving plant and in addition to the normal pruning, spraying and cultivation there are the needs of cover cropping and temporary and permanent shade. Nursery work and cultivation are at least as exacting as the requirements for ordinary temperate climate fruit trees.

(*a*) *Choice of Site.*—

Coffee is fairly tolerant to a wide range of soils and altitudes, but reaches its best development on a deep, well-drained soil with a high humus content and a slightly acid reaction. It does not tolerate very acid soils as well as tea and a pH value of 6-6.5 is optimal. Alkaline soils with high pH values are detrimental and cause stunted growth and chlorosis or yellowing.

A reasonably high and well-distributed rainfall is also important in the growth of the crop.

(*b*) *Nursery Work.*—

The young coffee bush develops slowly at first and must always be grown in a well-prepared nursery. The cleaned seed has a ventral groove which assumes importance in planting; correct planting requires that this groove be on the underside when the seed is sown. Unfortunately coffee seed retains it viability for only a short period; excessive drying is deleterious and the life of the seed is lengthened somewhat if it is stored in moist charcoal.

The seed normally takes six weeks to germinate and a further period of nursery growth for at least six to nine months is required before the young trees reach the usual planting-out height of twelve to eighteen inches.

(*c*) *Use of Shade.*—

Except under very unusual circumstances, notably at high altitudes and in deep, shaded gully formations, adequate shade is a physiological necessity and has a marked effect on the uptake of potash and the carbon/nitrogen ratios. Strong winds are harmful to coffee and provision should be made for the establishment of windbreaks in exposed areas.

The tendency when shade is eliminated, except under special conditions, is for the development of umbrella-shaped trees which shed the lower laterals and develop crown scalding and early over-bearing to the detriment of the plant. Shade removal is sometimes resorted to in Asiatic countries in order to produce heavy crops in times of financial stringency, but it leads to sharply increased liability to plant exhaustion and physiological diseases such as die-back (often also associated with the fungus *Botryodiplodia* spp.).

It was stated during a Rural Radio Talk on coffee over 9PA that under New Guinea conditions, coffee grown without shade will crop itself out. This talk has been reproduced in the *Papua and New Guinea Agricultural Gazette*, Vol. 8, No. 2, pp. 69-71, and should be referred to by the reader. This is considered to be generally true although there are probably some conditions here where, as in Kenya, the use of shade is not absolutely necessary. If a grower wishes to establish a permanent plantation it is essential that he control the cropping of his coffee and the only economical way to do this is by shade manipulation. Only experience will show what degree of cropping can be permitted on a particular plantation without damaging the trees. So that shade may be varied when necessary care should be taken to select permanent shade tree species which will stand lopping.

The Department strongly recommends the use of permanent shade for coffee wherever it is grown in Papua and New Guinea. When planning the initial shade density, the grower should bear in mind that it is much easier to remove shade than to establish it in an old coffee area. Hence at low levels, using *Leucaena glauca* as the permanent shade, an initial density of ten feet by ten feet is recommended and on the Highlands where larger permanent shade trees such as *Albizzia* and *Grevillea* spp. are used, a minimum initial stand spaced twenty feet by twenty feet is considered suitable. The shade can be side-pruned to get the maximum height and diffusion and also thinned as may be necessary.

For temporary shade, *Crotalaria anagyroides* is generally accepted as the most useful species, especially in the Highlands, but *Tephrosia candida* and other quick-growing legumes may also be used.

(*d*) *Cultivation.*—

In discussing the question of cultivation it must be realized that coffee has two types of rooting systems. The main tap root goes deep to water and injury to this root can cause stunting or even death of the plant. The numerous fibrous feeding roots form in the surface layers of the soil and are most important in the nutrition of the coffee plant. Deep or excessive cultivation can cause serious damage to these roots and thus damage to the plant. It is important that coffee should be kept fairly clean and especially must the strong-rooted grasses be removed because of their heavy competitive effect. At the same time it is equally important that cultivation be shallow and disturb the coffee roots as little as possible.

The surface roots of coffee are capable of feeding on quite raw humus, a characteristic which is found much more frequently in tropical than in temperate climate plants. Just dead or browning leaves of the coffee plant itself as they fall are readily attacked by fibrous roots breaking through the surface of the soil.

For the scientifically minded, it may be stated that this power of the coffee plant to assimilate raw humus has been partly ascribed to the association of *mycorrhiza* (symbiotic fungi) with the feeding roots of the plant.

Maturity and Longevity of the Coffee Plant.

Generally speaking the first worthwhile fruiting is obtained from Arabica three to four years and Robusta two to three years after planting out, although light fruiting is often obtained earlier. The first trimming or pruning will be required during the second year of growth. Early bearing at, say, two years should not be encouraged as it may interfere with the development of a sturdy bush.

Profitable production per plant can be expected in five to six years. Profitable production at the plantation level will depend on the speed of planting up of the original area and is thus usually a couple of years later. Maximum bearing can be expected in seven to eight years and should continue until the plants are twenty-five to thirty years old although plantings made under unfavourable conditions will die out early. With careful management good, sturdy plants may survive fifty years. Rejuvenation and grafting of old trees can considerably extend the life of the plantation under certain circumstances if carried out under favourable weather conditions; heavy losses may ensue if rejuvenation be attempted in dry weather.

The economic productive life of a plantation should be assessed at about twenty years when calculating costs, risks and depreciation in connection with coffee plantation work.

Further Information.

Comprehensive modern books on coffee culture are rare and difficult to obtain; this is especially true of those which deal with practical planting and production. For example the well-known text, *Coffee in Kenya*, by McDonald, printed by the Colony and Protectorate of Kenya Department of Agriculture in 1936, is out of print. This is an excellent publication on Arabica coffee although not all its recommendations apply to local conditions in the Territory where there are differences in soils, climate, labour, etc. Efforts by the Department to obtain extra copies for planters have been unsuccessful.

The Department of Agriculture, Stock and Fisheries employs a number of Specialist Officers in various spheres who will contribute more detailed articles on coffee in future issues of this *Journal*. The fields to be covered include Plant Pathology, Entomology, Soil Chemistry, Soil Surveying, Agronomy and Agricultural Economics. A number of Officers of the Department have been abroad studying coffee production in Hawaii, West Indies and Trinadad, Indonesia, Malaya, Africa and India. Many problems which arise can, however, be answered only by local experiment and trials are being laid down on Experiment Stations and growers' properties to provide answers to some of these problems. As well as Specialist Officers there are Extension Officers at main coffee-growing centres who will advise both on European plantation methods and Native coffee culture.

The Department has been fortunate also in obtaining advice on coffee growing from a number of overseas specialists, including Dr. Churchward of Anglo-Dutch Estates, Mr. J. Lincoln, Chief Adviser to Francis Peek Ltd., who are amongst the largest plantation companies in Indonesia and Malaya, Mr. G. K. Newton, a past president of the Planters' Association of Ceylon and a number of visiting Dutch experts. Australian processing firms give valuable assistance in assessing the quality of small samples from various regions and also from selected bushes. Their assistance in this way helps in advice on processing as well as in the selection of superior material. A representative of a leading Australian firm is expected to visit this country shortly.

Literature.

Several articles have been prepared on the subject of coffee growing at the request of the Department of Territories. The following brief list of publications, which will be repeated and added to at the end of this series, could also be consulted :—

(1) *Coffee growing in Kenya,* by J. McDonald. Colony and Protectorate of Kenya, Department of Agriculture.

(2) *Papua and New Guinea Agricultural Gazette,* Vol. 8, No. 2, October, 1953.

(3) The International Coffee Situation with special reference to Papua and New Guinea ; by Department of Commerce and Agriculture, Bureau of Agricultural Economics, December, 1947.

(4) The Production of Cacao, Coffee and Tea in the Territory of New Guinea. Department of Post-War Reconstruction, Regional Planning Division. Halsey, Canberra, March, 1948.

(5) Tea, Coffee and Cacao Review. 17/15 of 27.6.1947 F.A.O. and U.N.O.

The next article in this series will deal with some aspects of the establishment and cultivation of a coffee plantation.

NOTES ON KENAF "HIBISCUS CANNABINUS" PRODUCTION IN CUBA AND FLORIDA

J. C. LAMROCK, B.Sc. (Agr.), D.T.A.*

Kenaf as grown in Cuba and Florida originated from Java via El Salvador. As far as can be ascertained, the original sowings on a large commercial scale in El Salvador were carried out in the years 1943-1944. The original commercial sowings were destined for fibre production. The idea of growing the crop in Cuba arose due to the high export tariff placed on jute by Pakistan in recent years and the resulting activity of the United States Government in promoting the crop. At the same time the crop fits in well with the agricultural system of Cuba whose economy relies solely on the production of sugar. The Kenaf being a summer-grown crop lends itself to rotation with sugar-cane and the utilization of labour which is left idle after the cane cutting season in summer months.

The crop grown originally for fibre in El Salvador was bought up by Cuban interests and was allowed to grow for seed only. The El Salvador producer after this crop has never re-entered the field of Kenaf production. Verbal reports to hand state that the crop is now being produced on a small peasant scale in that country in order to supply local needs only.

The seed sold to the Cuban interests contained the so-called "viridis" and "vulgaris" types. No attempt had been made to separate these fundamental types besides known strains of such a heterozygous material.

With Pakistan still maintaining the export tariff on Jute and at the same time adding an extra loading on the fibre being sold to the United States, the United States Government, through the agency of its Commodity Credit Corporation, in 1950 contracted for Kenaf fibre to be delivered at Philadelphia at the following guaranteed prices up to 1st May, 1953; 12, 18, 24 and 32 cents. (U.S.) per pound. These contracts were made with interests in Cuba, South Florida and Mexico. Seed for fibre production in South Florida and Mexico coming from Cuba, the seed in the case of the Cuban-New Guinea importation being of the basic heterogeneous stock.

Up to this period in late 1951, the production of Kenaf in Cuba had been biased towards the production of seed only, little thought in comparison from the commercial side being given to the production of fibre. The season 1952 saw production in all three countries aimed at fibre production only, the price of seed dropping from a $(U.S.).1 to 6 cents (U.S.) per pound.

In Florida and Cuba, due to the cost factor, the emphasis during the 1952 season had been placed on the mechanical production of fibre in lieu of hand labour methods as in the case of Mexico.

The young industry in Cuba and South Florida has ended for the present, the 1953 sowings being in the neighbourhood of 50 acres by a commercial undertaking which is still persevering with the crop. The collapse of the industry during the 1952 season was due to lack of forethought and lack of suitable processing machinery coupled with the advent of Anthracnose disease (*Colletotrichum hibisci*) which became manifest in commercial plantings in the 1952 season.

At the present time of writing there is no commercial production of the crop either in Cuba or Florida, except the small acreage mentioned before, being grown at Bayamo by the North Atlantic Fiber Corporation. However, the future holds much promise for the crop and active research now being carried out from the agronomic and engineering fields points to a sound future.

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The research work in Cuba is being carried out by the Co-operative Fiber Commission. The U.S. and Cuban Governments both supply technicians and funds on an equal basis. The work in Florida is being carried out by the U.S.D.A., Division of Plant Industry, Soils and Agriculture Engineering in co-operation with Florida State University.

Soils.

The soils utilized for Kenaf in Cuba have been generally run down cane land of the red earth group. Initial plantings on these lands have given satisfactory crops but second plantings have been generally poor. The use of these low fertility soil areas has been manifestly due to their availability and lower rental charges. The work done in experimental fertilizer trials has shown that on this class of soil the crop quickly responds to nitrogen and phosphate applications.

In the case of Florida Kenaf—the crop is being grown on organic muck soil containing no mineral matter, the crop responding to phosphate and potash applications. Owing to unique genealogy of the muck soil, the whole area is more or less trace element deficient and Kenaf as well as all other commercial crops in the area responds to copper, zinc, manganese and boron applications.

The only sign of trace element deficiency in the crop appears to occur in Cuba on a mineral soil. The symptoms of chlorosis only occur in small localized spots. As yet, nothing definite is known about it conclusively.

Agronomy.

As stated previously, in Cuba the Kenaf crop lends itself to the agricultural practices of the country. It is the same story in the South Florida region. In South Florida on the muck soils of the everglade area, the main crop is winter grown vegetables, the land for the greater part of the summer months lying idle. In both countries the crop is an essential one from the standpoint of a self-sufficient economy, besides its export trade possibilities.

Experience in these countries with the crop, has been most interesting, especially in the factor that the crop is being cultured in the temperate and sub-tropical zones as against its cultivation in New Guinea, which is well within the tropics. This fundamental factor, besides showing the crop's versatility, also governs every aspect of its cultivation and cultural habits.

The length of day has a deciding influence on the time of sowing and the utilization of the crop. Sowing early in the spring means that the crop is utilized for fibre whilst sowing in the autumn-late summer period in shortening day length results in the crop being grown for seed only. The same material in long days grows to a height of 8-12 feet as against 3 feet 6 inches to 5 feet during short days.

The foregoing factor controls sowing rates and sowing distances. At the same time, varietal characteristics have a governing influence also. As yet figures for these factors have not yet been proved conclusively for the crop for the best results.

The basic criteria which is used as a rule of thumb so far is that for fibre production, sowing should be heavy in the order of 20-30 pounds per acre, with a spacing distance of 7-12 inches, for seed production the sowing rates being lighter in the order of 8-15 pounds per acre and spacing being in the order of 10-24 inches.

In Cuba under certain conditions of high rainfall, it has been observed to be possible to grow a fibre crop, cut it and allow it to ratoon and harvest as a seed crop. This may have big possibilities where irrigation facilities exist.

The main problem with the crop from an agronomic and economic point of view, is to produce a fibre crop over an extended harvesting period, in order to obtain maximum utilization of harvesting and processing equipment and at the same time preventing marked fluctuations in the number of labour required through the year. It is stated that for the crop to be economic in considering the capital investment for equipment, the crop must be in production for a minimum of six months, that is six months continual harvesting for fibre. An optimum harvesting period for large scale commercial undertakings being given as eight months. So far in Cuba using the present existing varieties, production can only be maintained for a four and a-half to five month period.

This question is of great importance to New Guinea wherein day length and temperature factors are more or less confined to a narrow diurnal and seasonal range.

There is little difficulty in weed competition, once the crop becomes established after the seedling stage. All weed control investigation work has been aimed at pre-planting control. This can either be done by the use of general cultivation implements in the case of nearly all weeds. An exception is in the case of Morning Glory (*Convolvulus upsi*) which will persist and finally may smother the crop. A big danger with this weed is that its seed and the seed of Kenaf are difficult to mechanically separate. In some instances in Cuba and Florida, plantings of the crop have been abandoned due to sowing of a Kenaf-Convolvulus seed mixture.

The use of hormone weedicides have shown promise for weed control for commercial practices, one-quarter pound 2-4D ester per acre, two to three weeks prior to planting, has been recommended.

As yet, nothing definite is known about Kenaf's place in a crop rotation. Cuba is the only place where some thought has been given to this problem. A crop rotation experiment has been started but it will be a few years hence before any definite information comes to hand.

Both in the case of Cuban and Florida soils, a big danger to Kenaf production is nematode infection. The nematode affecting Kenaf in Florida has been classified as *Meloidogyne incognita.*

The question of nematode control revolves about the question of crop hygiene and crop rotation, so far maize being the only feasible crop to grow in a rotation.

Chemical sterilization of the soil for nematode control has been undertaken in Cuba during the 1952 season. The following chemicals have been used in experimentation—D-D, C.B.P. 55, Chloropicrin, Ethylene Dibromide (100 per cent. pure) —in conjunction with the following solvents —Kerosene, Alcohol and Xylol.

The nemacides were applied to the soil six weeks prior to planting. It was observed that the nemacides may have a possible effect as a weedicide.

Chloropicrin appeared to be the best nemacide but in considering the cost factor and results, the use of ethylene dibromide is to be further investigated as well as the effect of Xylol as a solvent.

As yet, no serious insect pest has shown up in the Kenaf crop. Though it has been reported from Texas that Kenaf introductions were badly infected with Pink Boll Worm (*Pectinophora gossypiella*) and that it is unlikely that Kenaf will ever be grown in the U.S. cotton belt for this reason, as the Kenaf, growing out of season to cotton would serve as a harbour for the pest.

Physiology.

As yet, little is understood about the physiology of the plant. This lack of knowledge has been a great stumbling point for a sound plant breeding programme. This is especially manifest in the case of the so-called early, mid and late maturity types. The factors of maturity, photoperiodicity and temperature response being as yet unknown variables as listed :—

1.—*Photoperiodicity.*—

- (*a*) Effect on various stages of growth which may be correlated back to effective planting time.
- (*b*) Factors effecting floral inception.
- (*c*) Length of the vegetative period.
- (*d*) The breaking of the short day period, and the use of artificial illumination.

2.—*Thermoperiodicity.*—

- (*a*) Vernalization—the effect of cold storage of seed in relation to photoperiodicity.
- (*b*) Effect on internodal length.
- (*c*) Diurnal fluctuation of temperature in relation to plant metabolism.

3.—*Substrate Requirement.*—

- (*a*) Varying response to pH.
- (*b*) Tolerance to basic ions—calcium and magnesium.
- (*c*) Oxygen level and redox potential.
- (*d*) Calcium toxicity.

Breeding Programme.

Active plant breeding programmes have been under way in Cuba for the last eight years and for the last three years in Florida. The main factor which governs all breeding work at present is anthracnose (*C. hibisici*) resistance. In Florida the factors for resistance are claimed to be of a simple 3:1 segregation factor, whereas work in Cuba has tended towards a multiple factor theory.

Other factors which are considered in the breeding programme are as follows :—

1.—*Seedling Characters.*—

(*a*) Rapid emergence—related to seed size and hardness of seed coat.

(*b*) Rapid early growth—shade weeds.

(*c*) Resistance to disease and insect attack in the seedling stage.

2.—*Mature Plant Characters.*—

(*a*) Resistance to disease and insects.

(*b*) High yield of dry fibre per given area.

(*c*) Uniformity of plants for better machine efficiency—harvesting and processing.

(*d*) Strong fibre for better field handling, spinning and better finished product.

(*e*) Medium to fine stem for higher yield and better machine efficiency.

(*f*) Faster retting types.

(*g*) Types reacting better to mechanical and chemical extraction.

(*h*) Types of varying sensitivity to length of day for more efficient use of production and extraction equipment.

(*i*) Types of varying sensitivity to rainfall and temperature patterns.

3.—*Seed Characters in the Mature Plant.*—

(*a*) High yield of viable seed.

(*b*) Medium hard seed coat. (Soft enough for rapid emergence and hard enough for longevity under storage.)

(*c*) High oil content—a type for the oil market.

(*d*) High protein content—foodstuffs.

(*e*) Non-shattering types.

(*f*) Reduction of spines in the capsule.

Pathology.

Prior to May, 1952, there was no organized pathological work on Kenaf being carried out.

The onset of Anthracnose disease during the 1952 season was the principal reason for workers turning their attention to the disease of this crop. The bulk of all this work has been carried on in Cuba and considerable knowledge has been accumulated, especially with Anthracnose. In the case of this disease, the casual organism has been isolated from stem tissue, leaf spots and stem cankers; its pathogenecity proven and finally represented by 32 strains all virulent. These strains have been used in the hand inoculation work of all of the 48,000 individual Kenaf plants in the Cuban breeding plots.

Diseases of Kenaf in Cuba.—

(*a*) Root and Collar Rots—

(1) Collar Rot—*Sclerotium rolfsii.*

(2) Charcoal Rot—*S. bataticola.*

(3) Root Rot—*Phytophthera parasitica.*

(4) Seedling Root Rot—*Rhizoctonia solani.*

(5) Physiological Root Rot.

(*b*) Stem and Leaf Diseases—

(1) Black Stem Spot—*Nectria* spp.

(2) (*a*) White Stem Spot—*Pelliculraria filamentosa.*

(*b*) Zonate Leaf Spot.

(3) Anthracnose — *Colletotrichum hibisci.*

(4) Mildew, powdery—*Leveillula taurica.*

(5) Deficiencies.

(6) Mosaic—Virus.

Harvesting and Processing.

The harvesting and processing of Kenaf is still more or less an open book. No method has been proved conclusively to be the best and the most practical one.

The first object in the growth of Kenaf is to maintain a seed supply and in doing so, if possible, to recoup fibre from the seed producing plants.

The harvesting of Kenaf seed revolves around the use of two principal methods. First, the harvesting of the seed in the standing crop by the use of an all-crop harvesting machine and then cutting the standing "stubble" by the use of hand labour or binders followed by the use of some processing operation.

The other method used in some cases is to cut the seed crop by using a binder and to stook the cut sheaves and allow the seed to dry on the plant. The material then being passed through a stationary thresher for the recovery of seed and then the resulting stem material being processed for fibre.

The governing factors which control either method which have been tried on a rather limited scale is first, the weather. In high rainfall areas the use of the all-crop harvester is the most practical as the seed can be harvested on the green side and finally be dried in artificial dryers. The main difficulty in this practice, which in turn favours the stook method, is that the height of the crop makes harvesting operations difficult and the seed yield is much lower owing to the restricted period of time the crop is harvested in regard to the floral habit of the plant.

The use of the binder and stooking method does not require a high capital investment for equipment (harvester and drier) as the machine is used for fibre production also. Again, seed yield recovery is ten to twenty per cent. greater, and at the same time the crop residue is in a state which makes for easier transport, handling and processing. It has been stated that yield of tow fibre may be 200 to 300 per cent. greater than that of a combine harvested crop.

Unfortunately, no serious experimental work has been done in this field in order to obtain more explicit information. The question will undoubtedly rest upon the economics of cost of seed and tow recovered per acre, and the most economic proportion of each.

One of the big problems in seed production is the purity of the seed. As yet, no mechanical device has been manufactured to give 100 per cent. separation of Kenaf and its major weed pest, *convolvulus*.

The question of the best harvesting methods of Kenaf for fibre is as yet unanswered specifically.

The main factor which hinders production of the crop is that the producer whilst being an agriculturalist in growing Kenaf has also to be a semi-manufacturer in processing the crop. This processing factor immediately governs the type of producer, either a large commercial establishment with capital to install costly processing machinery, or again a peasant producer turning out small quantities produced laboriously by hand. As yet, there is not much opening for the middle class producer which is the bulk of rural producers, as seen in a European country. There is some hope of the middle class section producing the crop if the industry, say, should follow the pattern of the sugar-cane industry, in produce being supplied for processing to a central plant owned either by the Government, private interests or a co-operative of the producers themselves.

Ideally, though, since the crop is in the non-perishable category, it is that the spinners, as in the wool trade, buy the raw fibre such as in the form of dry ribbon, which is easily produced by any of the agricultural classes, and processed into finished fibre as required for the looms during a twelve to twenty-four month period.

This concept of the spinner taking a more active interest in the crop is most important from the long range point of view as well as the short term view, in the development of the crop, and the position of Jute or any other short bast fibre crop in the world to-day.

The present problem is that with the high price of Jute products and its probable lack of production in the East in future due to unsettled conditions, there will be a greater use of bulk handling and kraft papers and other substitutes resulting in low demand for fibre packaging materials. This getting away from Jute and allied fibres is clearly witnessed in the U.S.A. at the present time. This state of affairs arising during the War when users of Jute products were forced to find substitutes due to its lack of supply. Substitutes were found mainly in the form of kraft papers; this industry has now built up its markets to such a proportion that Jute and its allied fibres are in a precarious position.

Jute and allied fibres such as Kenaf can quite easily recapture these lost markets, if it is produced at a competitive price. If this price is to be realized, the spinning manufacturer must take more interest in the crop and especially in Kenaf if it is to flourish as a major fibre crop. It is obviously in his interests to do so, if he is to compete with substitute packaging materials.

The cutting of the crop has been carried out in the greatest extent by converted John Deere rice binders fitted with a McCormick binder head. These machines have given fair results only. The main problem being that the machines were redesigned first to cut hemp and then put

on to Kenaf work. The machines are too lightly constructed for the Kenaf crop. Cuba and Florida interests have persevered with them and strengthened the machines as breakdowns occurred. In the case of Mexico producers, they reverted to hand labour and matchets for cutting the crop. Unfortunately, the machinery manufacturers are not interested in producing a more suitable binder at present, due to the small demand.

Inventive interests and small machinery firms are turning their efforts towards field decorticators and ribboners. Results so far tend to show that success will first be met in the field of ribboners, the field produced ribbons then being processed for fibre, either by retting, chemical or mechanical decortication.

The age-old method of retting, either the stalks or ribbons, has as yet not been superseded for a method of production. An interesting point which may prove a deciding factor in any processing method is experimental trials carried out by the U.S. Navy in 1952 on Kenaf sandbags. These bags, which were produced from fibre by mechanical decortication only lasted one handling due to rotting of the bag as against no rotting of retted fibre-produced bags. This fact has led the U.S. Military Authorities to purchase onlv retted fibre material.

Rot-proofing of mechanically decorticated fibre can be incorporated by giving such produced material a small final retting process, this process removing all free microbial substrate carbohydrate material. In future, it may be carried out by a quick-acting chemical treatment.

Machines which have been utilized for the production of ribbons are as follows :—

Meister Ribboner, Kiser No. 5 Test Kenaf Ribboner, Marti Ribboner, Alfab Kenaf Ribboner, Short Kenaf and Ramie Ribboner, Proctor and Schwartz Ribboner, Cary Harvester Ribboner, USDA Harvester Ribboner.

Machines for decorticating :—

Japanese Decorticator, Hubert Defibring Machine, Vencedora Decorticator, Krupp Stella Decorticator, Mohegan Decorticator.

Chemical Extraction.

Active research is now being taken in this field. It has been shown in the laboratory that the method has possibilities in the production of finished fibre.

The production of fibre from stalks or ribbons depends upon the breakdown or digestion of pectins—the main cementing material followed by the breakdown of the parenchyma cells consisting mainly of cellulose in order to free the independent fibres.

Sodium hydroxide has been found to be the cheapest substance for the extraction of pectin substances. The only trouble is that the concentration and temperature of the digesting media must be controlled in regards to the age and condition of the material to be treated. Digestion of the hemi celluloses of the fibre can easily take place, leading to fibre harshness and loss of spinning quality.

Soft soap and sodium carbonate (20 to 22 per cent.) solution gives satisfactory results in the digestion of the parenchyma material, the soap molecule attaching itself to the fibre and protecting it from the action of the sodium carbonate. Ammonium oxalate solutions have been extremely successful in producing fibre, but is prohibitive due to the cost factor.

Attempts are being made to use cheap sodium phosphate and borate salts as a digesting media.

The process appears to be impractical for quite a considerable length of time as yet. The disadvantages are the costs of the chemicals, especially soap, and the engineering problems of designing suitable equipment.

Research in Cuba is mainly centred on the problems of soap and chemical recovery. If whole or part of the soap could be recovered with more efficient use of digesting chemicals, the system would have something for it.

Proctor and Schwartz did design, build and install a continuous processing plant for Des Fibradores de Kenaf of Cuba.

The plant was a failure. This failure was due to the high cost of chemical for the process and the failure of the machine to

transfer the processing material through the various tank compartments. The latter difficulty being due to the failure of a suitable conveying system. When the material was partly digested, it lost its original form and the separating fibre wound around the conveyors, resulting in stoppages.

Retting.

Experimental work in Cuba and Florida has shown that retting may be divided into two stages. First, the respiration of simple carbohydrates within the plant cell followed by the removal of the pectinized bark, which may take a further 24 to 56 hours to take place.

This bi-phase of the retting process must be fully understood if the process is to be mechanized. The quick retting which occurs in the first stage may mask the second stage of retting and lead to the production of a poor grade of fibre. This has occurred with commercial retted fibre, both in Cuba and Mexico.

The second stage of retting of the bark pectins is receiving the greatest attention from the mechanization angle. The aim has been in all experimental and commercial work to reduce the time of retting in order to save on capital outlay in regards to the number of retting tanks, etc.

The aim of mechanization principles after the retting process has been to produce a satisfactory washer-burnisher machine. This is a machine which will remove shives and other foreign material, and at the same time leave the fibre in line for easier spinning. This operation of washing and preparing the finished fibre has been stated to be one of the greatest cost factors in the retting method, being costly in time, labour and water.

One interesting fact is that colour is no criteria of quality of fibre, but buyers are always influenced by colour. A buyer being biased personally towards a silky, white fibre every time. This colour of the fibre can easily be imparted by frequent washing in water, it being stated that three good washings will impart a most attractive appearance to an unattractive sample. This washing for appearance fits in best with the retting method, as washing is a normal procedure in the process.

PLANT INTRODUCTION METHODS

IMPRESSIONS GAINED DURING A VISIT TO FIJI

G. P. Keleny, B.A., D.D.A.

SUMMARY.

A comparison is made of the scope and functions of the Plant Introduction Stations in Fiji, Papua and New Guinea and Australia for the purpose of drawing general conclusions on the work of the various Introduction services. Closer collaboration in the importation, testing and distribution of plant material is advocated.

Introduction.

Throughout the world, there is a growing interest in plant introduction; as agricultural production and research expands, there is an ever increasing demand for additional crops or varieties that may meet a particular need in crop improvement or the encouragement of new rural industries.

Many of the Pacific Territories are too small to support a plant introduction service—such a service involving not only finding an appropriate source of plant material and the physical act of importation, but the observation of the new introduction under proper quarantine safeguards and multiplication prior to testing and distribution in the new environment.

Therefore, the South Pacific Commission has included plant introduction among its research projects in economic development (Project E. 1). In the course of this project, the Commission assisted the Fiji Department of Agriculture to maintain and operate an Introduction Garden at Naduruloulou.

The Department of Agriculture, Stock and Fisheries of the Territory of Papua and New Guinea established its own Plant Introduction Service to meet the requirements of the developmental programme envisaged for the Territory. Its Plant Introduction and Quarantine Station is located at Laloki near Port Moresby.

It was for the purpose of seeing the work at Naduruloulou and reporting on the possibility of closer collaboration and co-ordination between the two introduction services that the writer had the opportunity of visiting Fiji under the auspices of the South Pacific Commission.

The Introduction Stations.

The scope and policy of an introduction service is closely connected with that of the introduction station; in fact, the activities of the Station reflect the principal objectives of the service itself. Therefore, the differences between the Stations themselves are of some considerable interest in understanding the various policies that are being followed.

Laloki near Port Moresby, in the dry zone of Papua, is principally a quarantine and multiplication centre. The climate is not typical of other parts of Papua and New Guinea, and tropical species grown there depend on irrigation for their survival during most of the year. The non-typical nature of the area makes the Station suitable for quarantine purposes, but the maintenance of permanent crops is difficult under such conditions.

Except in special circumstances, all introductions are automatically sent to Laloki for quarantine, but once released from observation, species are forwarded to an Experiment Station for establishment, further testing and multiplication. In the case of annuals, seed from the first crop in the isolation area is often multiplied prior to distribution, but seedlings of perennials are forwarded to their appropriate environment soon after the conclusion of the quarantine period. A special isolation area, including an insect-proof lathhouse, is

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reserved at Laloki for growing initial introductions under quarantine observation. The plots in this area are widely spaced for proper inspection and to prevent possible cross pollination, while a regular spraying programme serves to reduce the insect population to a minimum.

The Plant Introduction Garden at Naduruloulou is situated on the fringe of the sugar-cane area in the wet zone of Viti Levu Island of Fiji. At the present stage of development one of the main objectives seems to be the establishment of parent trees of both local and introduced species (fruit trees, cacao, coffee, tea, etc.), for eventual distribution of propagating material; the other crops such as grasses, legumes and pulses are also being multiplied for distribution in Fiji and other Pacific Territories. Thus a permanent collection of economic and ornamental plants is a prominent feature of this Station.

Annuals introduced are tested for their suitability to Fiji conditions at the Principal Agricultural Station at Koronivia in the wet zone and the Sigatoga Agricultural Station in the dry zone. Often when the source of the introduction is considered to be reasonably safe from the quarantine aspect, portion of the original seed is distributed to the Experiment Stations for trial concurrently with the initial plot at the Introduction Station.

It will be seen that Laloki is mainly a multiplication centre, while Naduruloulou is a holding area for a living collection of plants. At the former, the testing of species is not possible on account of the long, dry season, while at the latter centre possibly the proximity of the Principal Agricultural Station reduces the pressure to carry out initial or preliminary observations in connection with introductions.

In contrast with the Territorial introduction services, the Plant Introduction Section of the Commonwealth Scientific and Industrial Research Organization is organized as a research unit. Plant material, often obtained as a result of overseas explorations by C.S.I.R.O. Officers, is grown at selected Stations for the purpose of ascertaining the basic analytical data for the species, i.e. yield, growth cycle, chemical analysis, etc. In other words, from a large range of introductions on the basis of several years observations and tests, plant introduction officers select those which can be expected to perform well in certain environments, either alone or in association with other species, and are worthy of further trial. At this stage, the material is gradually handed over to specialist officers of C.S.I.R.O. for more detailed work and further environmental studies. For this work, the Plant Introduction Section operates four introduction Stations, viz., at Canberra, near Brisbane, near Perth and at Katherine in the Northern Territory. The Officer-in-Charge of each Station is a Senior Research Officer who specialized in plant introduction for many years and is supported by research and technical staff. Systematic botanists, plant chemists, etc., are also attached to the Section.

All introductions are handled through the central office at Canberra, which makes the quarantine arrangements as applicable to each individual case, i.e. grown in a glass house, in isolation or in field plot. In their quarantine work, Plant Introduction Officers have the assistance of specialists of C.S.I.R.O. and the State Department of Agriculture, i.e. plant pathologists, entomologists, crop specialists, etc.

Plant Introduction Services.

Thus, by examining the functions of the Plant Introduction Stations we can infer the policies of the respective Departments. The Fiji Department of Agriculture is building up at Naduruloulou a collection of plants, which will act as a source of propagating material for demands from within or outside Fiji. The Department of Agriculture, Stock and Fisheries of Papua and New Guinea is introducing a range of plants, both annuals and perennials, for the testing of new crops and additional varieties that may be suitable for the varied conditions of the region from sea-level to the highlands, and from comparatively dry monsoonal areas to wet, tropical lands. The differences are particularly noticeable in the case of perennnial crops. In Fiji they are established and maintained at the Introduction Station for propagating purposes, while in Papua and New Guinea they are being grown at the Experiment

Stations and selected propagating material becomes available for distribution in the course of experimental work.

The Plant Introduction Section of the Australian Commonwealth Scientific and Industrial Research Organization has engaged in active plant exploration for the purpose of obtaining species of varieties (mainly pasture and fodder plants) to meet more specific demands arising out of conditions in certain parts of Australia. The introductions are tested by officers of the Plant Introduction Section, and followed to a stage where their behaviour and value in a particular, broadly defined environment is reasonably well established.

As can be seen, the general scope and purpose of Plant Introduction can be, and indeed has been, interpreted in a number of ways. However, it should be possible to define certain broad principles as the basic aims of an introduction service. The principal purpose should be to maintain a flow of material for research workers. It is considered important that every introduction should be made with a purpose in mind, i.e. one should look for species or varieties to meet certain required conditions.

These statements might be challenged on account of the relatively limited economic development in the South Pacific Region generally. It could be claimed that research facilities in many Territories are still limited, and that there are many crops, e.g. tropical fruits, which are known to flourish in similar environments elsewhere and could be imported for distribution without detailed preliminary experimental work. However, as research staff and facilities are expanded, there should be no need for casual importations.

The main emphasis of an introduction service should be on obtaining the material required for the experimental programme, whatever it might be, not on the number of introductions effected in a given time. In fact, it is thought that introductions should be limited to the number that can be safely and adequately handled and tested. Unless the Territorial Introduction Stations will be developed to a stage where they can carry out their own testing and selecting, the amount of material imported will have to depend on the capacity and scope of activity of the experiment stations and the extension service.

Techniques should also be developed to make possible the elimination, at an early stage, of those introductions which are unlikely to be successful or of economic importance, thus concentrating work on material which is most likely to warrant further attention.

However, pending the establishment of Botanic Gardens, it may be necessary to maintain stocks of viable seed of a wider range of plants. The viability of seed declines very quickly in the tropics, making it often difficult to keep from season to season. It is felt that the South Pacific Commission could assist with advice on the storage of seed in a viable condition in the tropics. Such information would be a great assistance to research workers throughout the Pacific Region.

Increasing attention is being paid everywhere to the need for strict quarantine measures to prevent the entry of pests and diseases. Thus, an introduction station must also be a quarantine station; in fact, it is thought that quarantine should be the prime function of Regional Plant Introduction Stations. Only then can they fulfil the purpose of protecting the areas as a whole from the introduction of pests and diseases. It should be the essential feature of a quarantine policy to reduce the number of points of entry to as few as practicable through the provision of well-equipped and staffed Introduction and Quarantine Stations. Thus, by supporting the principle of Regional Introduction Stations and, in fact, actively using the facilities available there, countries in the Pacific Region could effectively protect themselves from the further ingress of new pests and diseases.

Both Naduruloulou and Laloki could serve a much larger area in their respective geographical regions, should their facilities be required. Quite apart from making possible phytosanitary treatment and observation, limited and organized introduction would in itself effect a mathematical control, i.e. if the amount of a seed sample and the number of times it is imported is reduced, the risk involved is also greatly

lessened. Thus, disease-free material can be multiplied at the Stations for local and regional distribution.

The South Pacific Commission, it is felt, could stimulate the activities of the two Introduction Stations by giving greater publicity to their existence and regional functions. More information on the material available for distribution would also materially foster the interest of other Territories. Research workers and agriculturalists generally would then be able to obtain fresh supplies for their work, and in turn would indicate their interests and expected avenues of activities for the guidance of Plant Introduction Officers.

Thus true co-operation between countries and individuals could develop not only in the field of plant introduction, but also in all fields of agriculture.

Acknowledgments.

The author wishes to express his thanks to the South Pacific Commission for sponsoring his trip to Fiji and New Caledonia, to the Administration of Papua and New Guinea for permission to make the visit, and to Officers of the Fiji Department of Agriculture for their courtesy and assistance during his stay in the Colony.

This article was printed in S.P.C. Quarterly Bulletin, Vol. 4, No. 3, of July, 1954.

REPORT ON SURVEY OF VIRUS DISEASES OF FOOD CROPS IN THE TERRITORY OF PAPUA AND NEW GUINEA WITH SPECIAL REFERENCE TO PLANT QUARANTINE—PART II

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This survey was carried out in the course of travels in the Territory for the purpose of reporting on the incidence of bunchy top of *Musa* spp. in that region (see Part I) and was undertaken at the suggestion of Mr. R. E. P. Dwyer, Director of Agriculture, Stock and Fisheries, who was desirous of having the general virus disease position examined, particularly in relation to certain Native food crops, e.g. taro, kaukau (sweet potato), Cassava (tapioca), peanuts, corn, etc., as a guide to future quarantine action. The survey should be regarded as a cursory one and as being quite incomplete. The impressions were obtained from it, however, that the Territory has so far escaped a number of important virus diseases which are present in other countries and that the adoption of rigid quarantine would be of great value in the future development of agriculture in the Territory.

Special interest is attached to virus diseases because of the rather insidious means by which they may take control of a crop and the drastic measures which are usually required to deal with them once they have obtained the upper hand. Compared with blights and rots caused by fungi and bacteria which are usually conspicuous, virus infections may escape early notice and only become clearly evident when they have reached an epiphytotic phase or the whole of the planting stock of a crop is affected. Virus diseases are carried on from season to season by vegetative propagation which causes them to accumulate gradually and, in addition, most of them are transmitted from diseased to healthy plants by one or more insect vectors, which at times may allow them to spread with alarming rapidity. Transmission of viruses by true seed is the exception rather than the rule. Plant health authorities have come to regard virus diseases with special concern and the introduction of vegetative parts of plants to new territory now receives special scrutiny.

Plant Virus Diseases Seen in the Territory.

1. Aibika (Spinach) Mosaic.
2. Banana Mosaic or Infectious Chlorosis.
3. Canna Mosaic.
4. Cassia Mosaic.
5. Centrosema Mosaic.
6. Crotalaria Mosaic.
7. Corn Mosaic.
8. Cucumber Mosaic.
9. Pandanus Yellow Spot Mosaic.
10. Papaw Mosaic.
11. Peanut Mosaic.
12. *Piper Betle* Mosaic.
13. Potato Leaf Roll.
14. Taro Mosaic.
15. Tobacco Mosaic.
16. Tomato Mosaic.
17. Yam Mosaic.

Aibika (Spinach) Mosaic.—

A mosaic disease of Native spinach was noticed at Paragum, Gazelle Peninsula, New Britain, causing a light and dark green mottle and malformation of the leaves. Affected plants were also somewhat stunted. The relationship of the virus responsible for the mosaic is uncertain, but both tobacco plants affected with tobacco mosaic and bananas showing symptoms caused by the cucumber mosaic virus were present nearby in the same Native garden. No reference to a mosaic disease of aibika has been found in the literature.

Fig. 1.

Kaukau or sweet potato, one of the most important Native food crops, was found to be free from virus diseases. The "rosette" or "leaf curl" of this crop which is common in some parts of the Territory is believed to be caused by insect attack. A mosaic of sweet potato can be caused by the cucumber mosaic virus, but no sign of this disease was seen.

Fig. 2.

Cassava (or tapioca) in background, taro in foreground. In many parts of the tropics (e.g. Gold Coast, Congo, Cameroons, Liberia, Madagascar, Java), cassava is severely attacked by a virus disease. No sign of a virus disease was seen in this crop in the Territory, where it grows luxuriantly.

Fig. 3.
Mosaic disease of Centrosema. This is a valuable cover crop in many parts of the tropics, but is severely affected by mosaic throughout Papua and New Guinea and reduced in vigour.

Fig. 4.
Mosaic disease of Crotalaria, healthy foliage on right of photo. Crotalaria is widely used as temporary shade for plantation crops throughout the Territory but is almost universally infected with mosaic.

Banana Mosaic or Infectious Chlorosis.—

The occurrence of this disease in the Territory is referred to on page 21 of Part I of this Report. The disease is considered to be caused by one of the strains of cucumber mosaic virus and to be identical with that described in the literature by Wellman (12), Ocfemia (7) and the writer (5). It is regarded as unlikely that this virus will ever create a serious problem in this important food crop, although severe local outbreaks of the acute form of the disease may occur at intervals in areas where vegetable crops, particularly cucurbits, are interplanted with bananas. The chronic form of the disease generally has a minor effect only on plants and is probably not very infectious. It is the practice in New South Wales not to propagate from plants that carry even mild forms of the chronic infection and the adoption of a similar procedure in the Territory is suggested. It is not recommended, however, that banana plants showing mild symptoms of chronic infection be destroyed, but plants showing the acute form of the disease should be dug out when encountered.

Canna Mosaic.—

This disease is another manifestation of the cucumber mosaic virus (2, 10) but was encountered only once during the survey, namely, at Vunapope Mission, New Britain. It is recommended that affected plants be destroyed. In the Philippines (7) *Canna* spp. are regarded as important reservoirs of the cucumber mosaic virus.

Mosaic of Cassia, Crotalaria, Centrosema and other Leguminous Plants.—

Mild to severe mosaic mottling of the foliage, sometimes accompanied by pronounced stunting, is widespread in leguminous shade and cover crops (Figs. 3, 4), in most parts of the Territory. This disease is common in both highland and lowland areas.

It is not known whether one virus is the cause of the symptoms in all species or whether several viruses are involved. It is considered probable, however, that a single virus is responsible for most, if not all, the infections and that it manifests itself with a variety of symptoms according to the species attacked. In a series of adjacent plots of different leguminous plants at Mageri Agricultural Officers' Training School, Papua, mosaic symptoms were seen on *Centrosema plumeri*, *Desmodium* sp., *Uraria lagopodioides*, *Tephrosia* sp., *Crotalaria stiata* and *Dolichos hosei*, while *Calopogonium* sp., *Indigofera* sp., *Cajanus* sp. and peanut had escaped infection or were resistant to infection. Minor and doubtful symptoms were seen on *Stylosanthes* sp., *Clitoria ternatea*, *Stizolobium* sp. and *Poinciana* sp.

There was no evidence that the virus (or viruses) affected plants outside the Family *Leguminoseae* in any of the many localities where it was observed. It seemed also to have a somewhat restricted range even amongst leguminous plants. Thus, in some localities there was almost 100 per cent. infection in *Crotalaria striata*, *C. anagyroides* and *Desmodium* sp., while nearby peanuts (*Arachis hypogaea*) and beans (*Phaseolus* spp.) were unaffected.

A mosaic of Crotalaria has been described in the literature (3) but the causal virus has not been studied in detail. It is considered possible that the virus, which is widespread in many leguminous plants in the Territory, is that which is known as common pea mosaic virus (14). This virus has a fairly wide host range among leguminous plants, is transmitted by several species of aphids (*Macrosiphum gei*, *M. pisi*, *Aphis rumicis*) but is not transmitted through seed.

Corn Mosaic.—

Mosaic disease of corn was seen in only one locality, namely, in a plot of young corn at the Teachers' Training School, Sogeri, Papua. A portion only of the plot was affected. There are two mosaic diseases of corn and the symptoms of mottling resemble those carried by the cucumber mosaic virus in corn (13) rather than those of leafhopper-transmitted corn mosaic (4). A colony of aphids, presumably *Aphis maidis*, was present on some of the affected plants and there were no signs of leafhopper feeding marks.

Cucumber Mosaic.—

The host plant range of this virus is very wide (2, 10) and it is the writer's opinion that the virus is fairly widespread

in the Territory where it causes a number of diseases, e.g. mild cucumber mosaic, acute and chronic banana mosaic, corn mosaic, canna mosaic, mild mosaic of papaw and mild mosaic of passionfruit. In no instance, however, were serious outbreaks attributable to this virus seen. The outbreaks were mainly local ones and indicated that a few infective aphids had spread from a restricted infection centre. This position is different from that which obtains in some tropical countries, e.g. Hawaii, North Borneo, Florida, Mindanao, where it is usual to find common weeds such as *Commelina nudiflora* and wild grasses infected with this virus. As a result epiphytotics of diseases caused by different strains of cucumber mosaic occur from time to time in neighbouring crop plants. It is thought that it is inevitable, as European settlement expands, that the weeds and grasses of the Territory will also become widely infected with cucumber mosaic virus. The virus is known to be disseminated by the seeds of a number of its host plants and several different species of aphids are capable of transmitting it with high efficiency.

Under tropical conditions, cucumber mosaic virus appears to have a less destructive effect on some of its host plants than it does in temperate regions. Although symptoms are present they are mild or masked. This applies particularly to cucumber and passionfruit and evidence of this was seen in both the lowlands and highlands of the Territory. Special interest attaches to passionfruit where the symptoms of infection are so slight that they would escape notice except by one familiar with the variations of symptoms of this virus in this host with seasonal conditions. In Australia, cucumber mosaic virus causes the widespread mosaic or woodiness disease of passionfruit and the severity of symptoms fluctuates greatly between winter and summer because of the masking action of temperature. In both the lowlands and highlands of New Guinea the virus appears to be always masked and because of the suitability of the Highlands, e.g. Wahgi Valley, for fruit production by this vine and masking of the virus, the Highlands of New Guinea could prove in the future to be a very favourable area for passionfruit culture.

Pandanus Yellow Spot Mosaic.—

A striking yellow ring-spot mosaic was noticed in the Native school grounds at Matupit near Rabaul in small plantings of pandanus which were grown for basket work. The relationship or importance of this virus is not known.

Papaw Mosaic.—

The papaws of the Territory are surprisingly free from virus disease, but in one planting in the Saiho area near Popondetta, several plants which showed a mild mosaic of the younger leaves were encountered. The papaws were interplanted with cucumbers and corn and it is considered that the mosaic symptoms seen may have been another manifestation of the cucumber mosaic virus.

In the Highlands of New Guinea, at Nondugl and Mount Hagen, almost every papaw plant showed a conspicuous mottling (of light and dark green areas) of the younger foliage. The vigour of the plants was unaffected. This mottling, which superficially resembles a mosaic of virus origin, is caused by infection of young foliage by the powdery mildew fungus (*Erysiphe* sp.).

Peanut Mosaic.—

Special attention was paid to peanut crops with a view to determining whether peanut rosette (11), a serious virus disease of this plant, occurred in the Territory. No sign of the disease was seen.

A single plant which showed a severe leaf mottle and was stunted, was found in a crop of Virginia Bunch at Bubia Experiment Station, near Lae. The symptoms bore no resemblance to those of peanut rosette and are considered most likely to have been caused by a chance infection by the virus which is common in Crotalaria and Centrosema in the Territory. Even if this is so, peanuts must still be regarded as highly resistant to this virus.

Mosaic of Piper Betle.—

The occurrence of a virus disease of this plant in the Territory is of interest since the betel vine (*Piper betle*) is closely related to pepper (*Piper nigrum*) which is a possible crop of the future. A mosaic disease of *Piper betle* was seen in Native gardens

near Rabaul. Although the mottling of the foliage was conspicuous, the vigour of the affected plants was still satisfactory. No reference to a virus disease of *Piper* spp. has been noticed in the literature, but it is thought likely that *Piper nigrum,* which is propagated vegetatively is commonly affected with a virus disease in Java. Last year, canes of the broad leaf and narrow leaf pepper from Java were intercepted in quarantine in Sydney and all canes in the consignment were found to be affected with mosaic.

Potato Leafroll.—

This disease (10) which is one of the serious "degeneration" diseases of potato, is to be seen in most crops in the Highlands of New Guinea. The disease is carried in the tubers and is spread by a number of species of aphids. Presumably, the disease has been introduced to New Guinea in seed potatoes from Australia. A crop of potatoes being grown at Wau from New South Wales certified seed contained a percentage of leafroll plants. The Department of Agriculture, Stock and Fisheries is developing a potato seed raising project at Aiyura Experiment Station (altitude 5,500 feet) using virus free stock. Most of the important varieties of potatoes have been imported and as soon as sufficient seed for distribution is available from this project it would be advisable to restrict further importations of seed potatoes to the Territory with the object of retarding entry of the spotted wilt virus (which has a wide host range) and potato blight (*Phytophthora infestans*).

Mosaic of Taro.—

Taro (*Colocasia antiquorum*) is important as a Native food crop in most parts of the Territory, and in most areas is affected with a mosaic disease. The disease appears to have an acute form and a chronic form and the different varieties, which are usually intermixed in Native plantings, seem to vary in sensitivity to the virus. The acute form causes marked stunting of affected plants, with chlorosis, twisting and malformation of the central leaves. The symptoms of the chronic form are variable, ranging from a prominent yellow mottling or streaking of the leaves without much malformation (Fig. 5) to an almost imperceptible minor streaking of the foliage. In some districts, e.g. Lae, the Native women in propagating, avoid severely affected plants and succeed in establishing improved stands. This disease is regarded as an important one, being somewhat equivalent in its degenerating effect to leafroll and the mosaic diseases of potato in European countries and it is thought that means of overcoming it should be investigated, for instance, at Keravat Experiment Station.

A search of the virus disease literature has not revealed any investigation of a virus disease of taro. The possibility should be entertained, however, that the disease is caused by the cucumber mosaic virus. Many monocotyledonous plants are susceptible to this virus and such infections frequently have an acute and chronic phase. Further, this virus is fairly widespread in the Territory on other hosts.

Some attempt is being made at Keravat Experiment Station to improve taro crops by roguing out severely affected plants. It is suggested that this system be modified to one of selection of apparently mosaic-free planting stock for replanting in isolation.

Reference should be made here to the disease which is reported to have wiped out taro crops in Bougainville and the British Solomons in 1946 and which was at first considered to be a virus disease (1). The disease has since been identified (8) as leaf spot and blight caused by *Phytophthora calocasiae.* During a brief visit to Buka Agricultural Experiment Station an endeavour was made to examine this disease but it was reported that the phythophthora disease had also "wiped out" the taro crop of Buka. Phytophthora leaf spot and blight occurs also in Hawaii (9) where a fair degree of control of it is obtained by spraying at intervals of about ten days with 4.4.50 Bordeaux mixture. Kongkong taro, *Xanthosoma macrophylla,* is resistant (15) to this disease and observations in the Territory indicated that this taro is also highly resistant to mosaic. Natives are reported, however, not to favour the variety, but it is being used successfully for Natives at Vunapope Mission, New Britain. There the crop is widely spaced and grown sufficiently long for the roots to become tuberous (about 15 months).

Tobacco Mosaic.—

This disease (2, 10) was present in almost all plants of tobacco seen in Lowland areas, particularly in the Gazelle Peninsula. It was seen also in the Central Highlands but symptoms there were milder as a result of masking by lower temperatures. The disease probably occurs in every part of the world where tobacco is grown. Although the virus is one of the most infectious it is apparently not regularly transmitted by any species of insect, nor by seed. Man seems to be the chief agent in disseminating the virus, since it is readily transmitted if healthy plants are handled after handling diseased ones, or if the operative is a smoker. The virus is a most refractory one and is not inactivated in the processing of tobacco. Since it is present in most tobacco crops it is also present in most brands of tobacco.

The tobacco mosaic virus has a relatively wide host range, particularly among solanaceous plants and is potentially important as the cause of a number of crop diseases.

Tomato Mosaic.—

Plantings of tomatoes were examined in a number of parts of the Territory and it was pleasing to observe that the spotted wilt virus (2, 10) has apparently not so far established itself in any of the areas visited. The tobacco mosaic virus, however, was seen causing a mosaic and a fern-leaf type of malformation in two crops of Bonny Best tomatoes grown by a European at Kubanga, Gazelle Peninsula. Control of this disease could be obtained by thorough washing of the hands with soap and water or allowing only non-smokers to transplant and attend to tomato crops.

Mosaic of Yams.—

A mosaic disease of yams (*Dioscorea* spp.) was encountered in a Native garden at Bumbi, near Lae. Time did not permit a survey of the Sepik District where yams are so important as a food crop. The disease caused mottling, vein clearing and distortion of the leaves with some reduction in vigour of the plants (Fig. 6). Apparently the disease has never been investigated, although there are scant references in the literature to the occurrence of a mosaic disease of the yellow yam in Sierra Leone in 1935 and in *Dioscorea* sp. in Puerto Rico in 1936. In the garden at Bumbi a small percentage only of the plants was affected by the mosaic so that it should be possible, by selection of planting material, to build up disease-free stocks.

Plant Quarantine in the Territory.

As mentioned earlier, the plant health position in the Territory is regarded as surprisingly good, particularly when one realizes that a great many introductions of plants have been made over the years. In addition to inspecting food crops, some observations were made on coconuts, cacao, coffee, quinine and tea and the impression of these crops, too, was that no serious introduced disease was causing losses. Most of these crops were subject to root and bark rots which have spread to them from the jungle and the few other diseases seen appeared to the writer to be caused by the use of unsuitable localities for the crops. In the case of a leaf malformation and yellowing of Robusta coffee at Keravat Experiment Station, an undetermined soil nutritional factor seemed to be involved.

Most countries of the world have established a plant quarantine service in order to avoid or slow down the entry of new diseases, pests and weeds and while there are the beginnings of such a service in the Territory, there is a need for precise legislation as a basis for future development. The *Quarantine Ordinance* 1931-1938 of the Territory of New Guinea and the Plant Diseases Ordinance of the Territory of Papua provide a suitable framework on which a plant quarantine organization could be built up, but there is need for a supporting series of Proclamations declaring ports of entry and naming specific diseases for the purposes of the Ordinances, plants which are prohibited as well as drafting of Regulations governing procedure in connection with seeds or parts of plants to which it is desired the Ordinance should apply.

The exclusion of plant diseases from an importing-exporting country presents many problems. In some regions, e.g. North America, an elaborate, highly restrictive and costly quarantine has been devised to achieve this end, but few countries can afford the luxury of staff to operate such a

Fig. 5.

Taro, one of the favourite Native food crops, is affected with an acute and a mild form of mosaic in most parts of Papua and New Guinea. The central leaf in the photo is showing the mild form of the disease, which has only a slight effect on vigour. The acute form dwarfs the plant and malforms the leaves.

Fig. 6.

Showing left, mosaic disease of yam and right, healthy foliage. The disease causes mottling and severe malformation of the leaves.

scheme or are sufficiently self-supporting to bear the interference with commerce the restrictions involve. It is doubtful, too, whether the best organized schemes do not sometimes break down, through first-class mails or by surreptitious imports.

It is considered that the most publicly-acceptable and workable quarantine scheme is one aimed at protecting the principal crops of the country and which prohibits imports of such plants, or allows entry of them only from sources where a disease of importance does not occur. Plant pathology is becoming well developed in most countries and accurate records of the geographical distribution of the more important diseases are now available from the Distribution Maps of Plant Diseases issued, and kept up to date, by the Commonwealth Mycological Institute, London.

A system of plant quarantine based on the above principle is the one advocated for the Territory, with care being taken to interfere as little as possible with the free movement of items of commerce and food. The main export crops which need protecting are well defined, possible future export crops can be envisaged and the principal Native and European food crops are well known. For practical purposes, and until disease surveys are more complete, it can be assumed that existing crops of the Territory are free from important diseases.

The present provisions of the *Quarantine Ordinance* 1931-1938 does not distinguish between plants (all plant parts) whether principal crops or merely items of commerce or food. If this Ordinance was enforced all plant material entering the Territory would have to enter through certain ports (not yet specified) and be submitted to the prescribed inspection. It is considered that this section should be modified or suitable Proclamations issued, prohibiting entry of specified plants, e.g. coconut, rubber, cacao, coffee, tea, cotton, sugar-cane, banana, abaca (Manila hemp), papaw, sweet potato, taro, cassava, peanut and other principal crops. Provision should be made for entry of limited quantities of seed or propagative parts of the above crop under permit from the Director of Agriculture in order to keep the Territory supplied with new or improved varieties. It is doubtful whether control of entry of fruit, seed and propagative parts of temperate-climate fruits, vegetables and ornamentals should be restricted at this stage, because of interference with commerce and food supplies, unless there is a specific reason. Thus, potato and dahlia tubers might be prohibited from countries where the spotted wilt virus occurs, e.g. Australia, because of the danger of introducing this virus which affects a very wide range of herbaceous plants. An important part of quarantine is public acceptance of the principles on which it is based and such acceptance is more easily obtained if quarantine is aimed at protecting specific and important crops.

The establishment of the Plant Introduction Station at Laloki, Papua, has been a step in the right direction. The Station is an irrigated farm in a dry area, is relatively isolated and well suited to the purpose for which it was designed. Entry of limited quantities of prohibited plants could be safely managed through this Station. Port Moresby would appear to be the most suitable Port for quarantine entry for both air and sea traffic because it is close to Laloki, but it will probably be wise to make Rabaul a port of entry also for certain areas. If this is done an isolated area at the Keravat Experiment Station should be demarcated as a plant introduction garden.

The above discussion takes into consideration only plant diseases, but the same general principles would apply to quarantine of insect pests and weeds except that closer port inspection must be maintained. One advantage of the prohibition system of principal crops is that a good deal of the port inspections can be carried out as a Customs routine.

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REPORT ON MECHANIZATION OF AGRICULTURAL CROPS IN NEW GUINEA

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Mechanization of Cacao, Lowland Coffee and Rubber.

THESE three plantation crops are discussed together because there are many points of similarity in the mechanization approach to cacao and coffee. There are wide points of difference between these crops and rubber but certain phases of rubber production have already been included in an earlier report.

Mechanization of these plantation crops is reviewed under four headings :—

(*a*) General Considerations ;

(*b*) Planting and Plantation Maintenance ;

(*c*) Harvesting ;

(*d*) Transport.

1. *General Considerations.*—

Emphasis is placed on the initial consideration that mechanization has to conform to the pattern of tropical conditions in New Guinea plantations. In particular, it is wise (a stark necessity in part) to restore as soon as possible after planting the natural forest processes of soil consideration and fertility maintenance. With sufficient humus forming and overhead canopies, the leaching from heavy rainfall is controlled and soil temperature is kept below the point where plant foods would be lost. The stark necessity of these needs is such that efforts are made to use the canopies of existing crops in the development of new ones. Hence the dual crop association of cocoa or lowland coffee planted between the rows of an established coconut or kapok plantation.

Mechanization can be used to make it less laborious and cheaper to control these processes to best advantage but it must not interfere with them to the disadvantage of the new crop. New Guinea temperatures, rainfalls and soil porosities cause rapid deterioration in soil fertility if the balance between the flora and the soil is disturbed. The process of building up fertility is rapid but not nearly so fast as its destruction, a process well described as violent. This speed in build-up and violence in destruction of fertility is the characteristic difference between the New Guinea Agricultural environment and that of temperate regions.

2. *Planting and Plantation Maintenance.*—

Land preparation for planting so far as clearing the land is concerned is a special study on its own. Planting the trees or bushes from a nursery is essentially a manual process under New Guinea conditions. There are transplanting machines available overseas of three main types designed for the following purposes—

(*a*) transplanting seedling trees ;

(*b*) planting grass sprigs and sweet potato slips ;

(*c*) transplanting vegetable seedlings.

These machines are on the border-line where small issues can decide whether their use is justified. They do not plant as well as can be done manually. Native labour is well adapted to planting work and probably is more efficient in this activity than in many others. Under these conditions, transplanting machines have an experimental interest only.

It is in the maintenance of the plantations that the major scope for mechanization lies. In cacao and lowland coffee, the plantation has to be kept clean of extraneous growth during the critical years when the shade tree canopy and the cocoa, etc., has formed its own forest association. The interspersal of shade trees with the cocoa narrows the room for manœuvring a tractor. The planting plan can modify this. The terrain and work of an average cocoa plantation favours the use of a light (20 to 35 h.p. maximum on drawbar) crawler tractor. If a wheel tractor were used, a 20 to 25 h.p. low clearance four-wheeled standard type would be likely to give the most general

Fig. 1.

Forest country (secondary growth) in the Warangoi area, Gazelle Peninsula, New Britain. The secondary forest growth illustrated is typical of the country which would have to be cleared. It is proposed to plant cocoa.

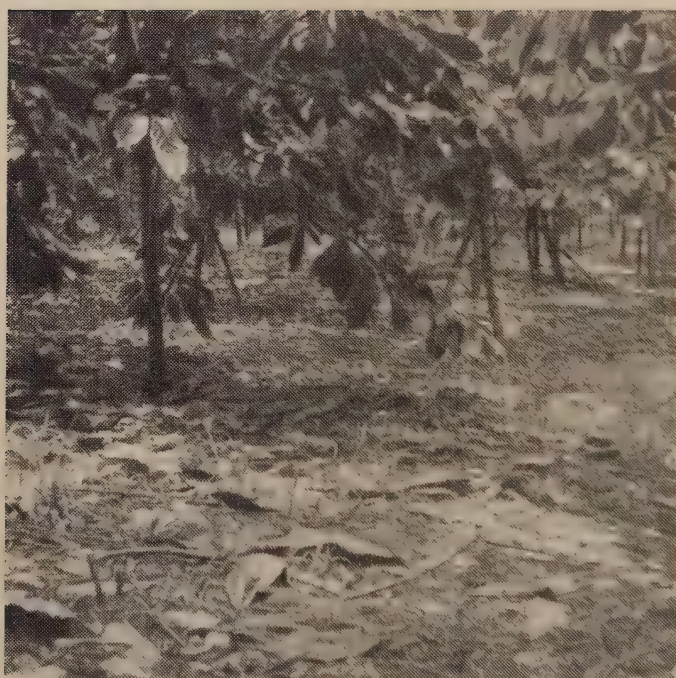

Fig. 2.

Young cacao plantation at Keravat Experimental Station, Gazelle Peninsula, New Britain. The protective canopy overhead cannot be seen.

Fig. 3.

Rotting vegetable debris on Rabaul cacao plantation. This protective ground cover of decaying matter is of vital importance in maintaining a relatively cool soil temperature—below sixty-eight degrees Fahrenheit. In association with the high and low canopy it gives a protection against soil erosion and excess leaching.

Fig. 4.

Illustration from a Madang plantation of soil erosion by rain-water run-off. It took only two or three weeks to do this on an unprotected hillside planted with sweet potatoes. This picture contrasts with Illustration No. 3 which shows a protective cover of plantation debris under a high canopy of legume trees and a low canopy of cocoa.

Fig. 5.

Lowland Coffee at Keravat Research Station. This illustrates a typical legume tree grown between the coffee bushes to provide a high canopy (similar to the canopy used to protect cacao).

Fig. 6.

Canopy formed by typical leguminous trees used to shade cacao and lowland coffee. The legume provides a high canopy which protects the cacao and the cacao provides a low canopy protecting the soil from the force of the raindrops and the heat of the sun.

Fig. 7.

Kapok and coffee association at Madang Agricultural Station. The kapok trees are used to provide a high canopy to protect the low-land coffee. A valuable crop of kapok is also obtained. The low ground cover is grass.

Fig. 8.

A close-up of coffee berries at Keravat.

Fig. 9.

Fermenting bin for cacao beans. Fleshy matter adhering to the beans removed from the pods is fermented off the beans in deep wooden bins.

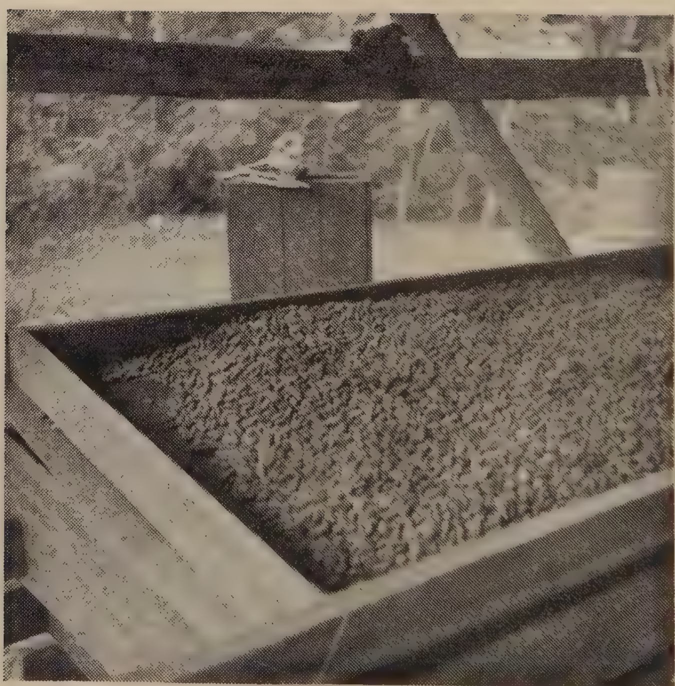

Fig. 10.

Cacao beans cleaned by fermentation and drying out in readiness for packing.

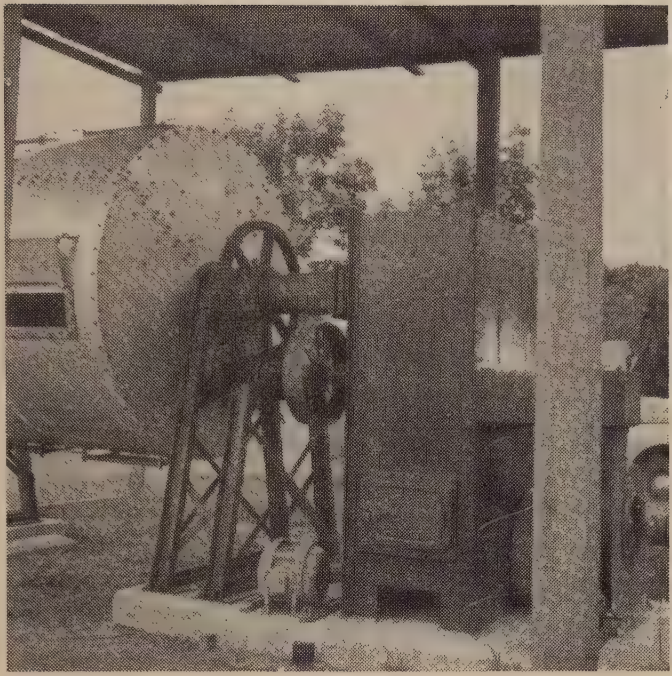

Fig. 11.

Coffee (and cacao) rotary hot-air drier, A.G.E. 5 h.p. 50 cycle 1,440 r.p.m. motor. The motor drives the rotary bin. A furnace and fan provides a current of hot air which circulates from the centre of the bin, through the beans and out through perforations in the sides of the bin. This plant is experimental so far as cacao bean drying is concerned.

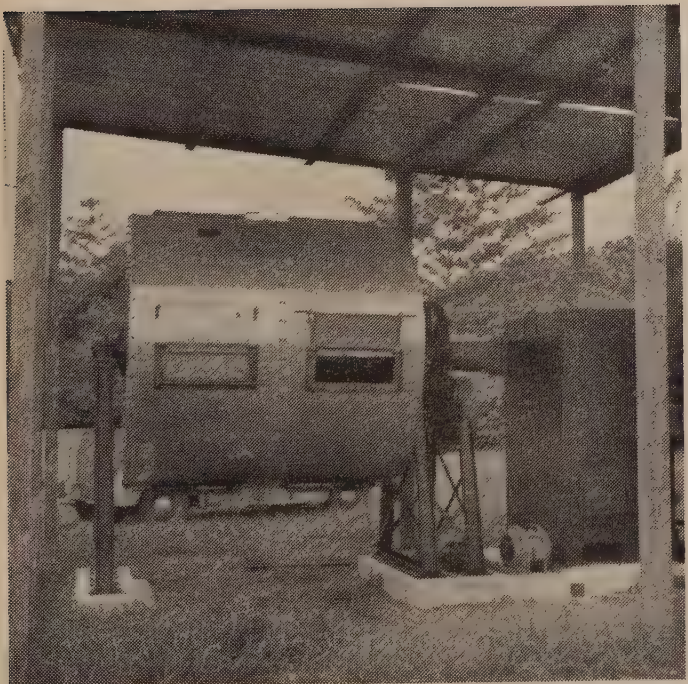

Fig. 12.

The rotary drier, showing a hot-air furnace.

service, there is scope for light bulldozer blades in clearing light scrub and forest debris. In the early stages of establishment of the young plantations there is no overhead canopy and "forest association" to keep the undergrowth and ground cover in check. The fern crushing machines described in the report on coconut plantation mechanization should be effective. Experimentally, work with several types is strongly recommended. The following makes are suggested for trial :—

(*a*) The Cuthbertson wheel-type bracken crusher; the details are described in the Report on Coconut Plantations. A seven-wheeled unit with an eight-foot cut would be available for rubber plantations, but for cocoa a smaller machine would be desirable—say a three or five-wheeled unit.

(*b*) The Australian "Robinson Woollard" bracken-fern crusher (see details in Coconut Plantation Report). The three roller unit would be suitable.

Uneven ground, logs and stumps will not prevent these machines from operating efficiently and at low maintenance cost. Operated with suitable weight they should control, without destroying, a legume ground cover.

The work of these machines might prove particularly effective in rubber plantations; there should be continuous control over the undergrowth during the whole economic life of the rubber trees. The typically rugged terrain of rubber plantations will not affect the efficiency of these machines. A light wheel or small crawler tractor of under 25 h.p. is sufficient power for haulage. The Australian machines can be drawn by two draught horses. If experiments are made with these machines, it is suggested that they be tried first in rubber and coconut plantations where they are likely to have the most use.

The terrain and work to be done is generally unsuitable for mowing machines. Small motor scythes such as the Allen Motor Scythe will be useful in a limited sphere and newly developed cutters employing some form of rotary blade may be worth trial (see the Hayter Cutter).

3. *Harvesting.*—

There is little scope for mechanization of harvesting. Keeping the plantations clean will be of material assistance. Mechanical field transport can help in the case of cocoa and coffee; this is mentioned below. The pneumatic principle for fruit harvesting now being developed in the U.S.A. and the United Kingdom will be worth close observation; particularly attempts in developing prototype machines equipped with flexible arms which can suck in ripe berries. The long-armed, pneumatic-powered secateurs (described in some detail in the Report on Land Clearing and Miscellaneous Crops) may have a use for harvesting cocoa pods. However, the present method is fairly efficient and the hand tools employed are inexpensive.

4. *Transport.*—

There should be a wide scope for tractor-trailers of the two-wheeled type, having a capacity of about two tons. This type of equipment is not expensive; with clean plantations such equipment would provide field transport in addition to general carriage; with a suitable tractor the combined unit would be manœuvrable and capable of work in uneven terrain. Transport in rough terrain could be organized manually to bring the crop (cacao and coffee) to central field depots where it could be picked up by the trailer.

TWO NEW INSECT PESTS OF THEOBROMA CACAO IN NEW GUINEA

J. J. H. Szent-Ivany, Ph.D. (Budapest)*

DURING an entomological inspection tour in the Madang District two new records of pests of cacao were observed and here briefly recorded :—

1. The adults of the Scale Beetle, *Aspidomorpha testudinaria* Montr. (Family Cassididae), hitherto known as a minor pest of sweet potato, were found in August-October, 1954, to be causing extensive leaf damage to cacao in two coastal plantations of the Bogia Sub-District. Related species (*Aspidomorpha miliaris* F., *amabilis* Boh., *micans* F.) were recorded as pests of *Ipomoea batatas* and other species of the Family Convolvulaceae from Indonesia (5, pp. 738-739).

The adaptation of *Aspidomorpha testudinaria* Montr. to the new host plant can be thus explained :—

During the extreme dry seasons of the years 1953 and 1954 the District Agricultural Officer, Mr. J. R. Vicary, observed that the Large Sweet Potato Hawkmoth (*Herse convolvuli L.*) appeared in unusually large numbers, causing considerable damage to *Ipomoea batatas* in the Madang District. Also *Aspidomorpha* appeared to be more numerous in the years 1953 and 1954. The defoliation of *Ipomoea batatas* by the large caterpillars of *Herse convolvuli* L. forced the adults of *Aspidomorpha testudinaria* Montr. to look for other host plants and in the Bogia Sub-District they found their way to *Theobroma cacao*, which proved to be a suitable subsidiary host plant. In one of the affected plantations sweet potato is used as a covercrop, thus the adults of *Aspidiomorpha* could easily reach the branches of the cacao trees. There are large patches of *Ipomoea* in the vicinity of the other plantation. The scale beetles, as good flyers, found their way in a short time to the cacao block.

2. Towards the end of the flying season of *Aspidomorpha testudinaria* Montr., the larvae of a small Limacodid Moth appeared in large numbers and caused 100 per cent. defoliation of the cacao trees, interplanted in a coconut block of about 100 acres. When the writer visited the plantation on the 3rd November, 1954, the trees in the block were practically leafless. Many of the blackened and shrivelled pods were affected earlier by a secondary infestation of Lepidoptera larvae. Up to fifteen empty brown pupae of a Tortricid (*Cacoecia* sp.) were found in some of the hollow pods. As secondary leaf- and pod-pests adults of the purple-winged Flattid *Paratella nivosa* Walk. were also observed.

No flowering cacao trees could be seen in the plantation and the branches of many trees dried out and broke off. The survival of some of the badly affected trees was doubtful.

The larvae of the Limacocid Moth seemed to be highly susceptible to D.D.T. As a result of spraying two per cent. D.D.T. with a knapsack sprayer by the planter on the 1st and 2nd November, most of the larvae found on the trees on the following day, were in a sluggish, half-dead condition, partly weakened by the lack of food. A large number of dead or dying caterpillars was lying under the trees.

Some odd larvae still had their bright yellow colour, but this turned to dark brown soon after they were transferred into a breeding jar, and they died during the next 24 hours. The small, light-brown coloured, cupshaped cocoons (with a diameter of three to four millimetres each), were found in concretions of up to fifteen on the end of the dry branches or in smaller groups or singly on the midribs of the chewed-off leaves. From 80 cocoons collected and kept in breeding jars, only four males and one female emerged in the course of the next three weeks. Several specimens of Hymenopterous parasites emerged in the period between the 5th November and 1st December, 1954. They represented two distinct species :—

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1. *Brachymeris salomonis* Cam. (Family Chalcididae).
   Eurytoma albotibialis Ashm. (Family Eurytomidae).

Both were identified in the Commonwealth Institute of Entomology, London.

The Limacocid Moth showed a remarkable sexual dimorphism and dichroism. The five specimens were sent to the Commonwealth Institute of Entomology for identification, they were examined in the British Museum and appeared to represent a new genus and a new species.

Even a part of the pupae seemed to be affected by the D.D.T. spray. Pupae found in the remaining cocoons four weeks after the emerging of the last parasite were all dead and in a shrunken condition, which indicates that the exitus must have occurred much earlier. This could have been partly a result of the weakening of the larvae through lack of food, which concluded in a sort of "forced pupation", a feature well known by lepidopterologists. The intrapupal metamorphosis, under such conditions, is often incomplete.

The new Limacodid Moth is believed to be a xerophilous insect and it is thought that the practically rainless dry seasons have caused the rapid growing of the moth's population. On the other hand, the parasites are most likely of more hydrophilous nature, consequently they have not appeared in adequate numbers before the beginning of the rainy season. The appearance of the parasites in large numbers and the lack of food, after the devastating defoliation of the host-plant most likely would have controlled the pest, without the application of the insecticide.

Most of the cupmoths (*Limacodidae*) are polyphageous insects. The new Limacodid seems to be also attracted by *Cocos nucifera*, as a concretion of cocoons was found on a fallen coconut frond. Other Limacodid moths are mentioned in the literature as pests of cacao and coconut in Indonesia (5, pp. 487-512) and in other parts of the tropical zone (Malaya, India, Philippines, Africa, Trinidad, Guiana, Argentine, etc.) (6, pp. 353-373). Larvae of an unidentified Limacodid moth were found on cacao foliage in 1938 in the Kieta Sub-District of Bougainville (3, p. 67). Another Limacodid moth (*Scopelode* sp.) from cacao foliage is mentioned in the Entomological Part of the Report of the Department of Agriculture in 1939 (4, p. 12). G. S. Dun recorded an unidentified species of the genus *Scopelode* from cacao found in New Britain (2, p. 25)*. The polyphageous Limacodid moth *Parasa lepida* Cr. was mentioned by G. S. Dun, causing serious attacks on 20 acres of coconuts at Hisiu Beach in Papua (1, p. 58). Kalshofen (5, p. 58) and Lepesme (6, p. 368) recorded *Parasa lepida* Cr. as a pest of coconut, cacao and other cultivated plants.

Rainfall figures of the Madang area are shown on Table No. 1, indicating an extremely dry season in 1953 and a very dry period in the middle of the dry season in 1954. The devastated cacao plantation is over 70 miles from Madang and the proprietor said that the season there was even drier, practically not an inch of rain being recorded between May and September, 1954.

Appreciation is expressed to Dr. W. J. Hall, the Director of the Commonwealth Institute of Entomology, London, in identifying the specimens, to the Meteorologist of the Department of Civil Aviation, Madang, and to Mr. J. R. Vicary for making available the rainfall figures.

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* J. L. Frogatt (locus citatus) mentions *Scopelode dp. and* G. S. Dun records *Scapelode sp.* (loc. cit.) from cacao. This is most likely a misprinting in both cases. It is believed that both represent species of the Genus *Scopelodes Ww.*, two species of which (*S. nitens* B. Bak and *S. dinawa* B. Bak.) are mentioned by Mr. Hering from New Guinea (7, p. 690).

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	1953		1954	
Meter. Station	Airstrip Madang.	Dist. Agr. Station Madang.	Airstrip Madang.	Dist. Agr. Station Madang.
May	7.52	9.05	26.82	Figures not available.
June	6.94	6.50	8.05	
July	4.06	5.47	1.73	
August ..	2.06	1.24	1.63	
Sept.	2.28	2.68	5.90	
Oct.	3.03	2.35	10.46	

Table No. 1.

Rural Broadcasts:

I.—COCONUT SEED SELECTION AND SELECTION OF LAND FOR PLANTING

IT is becoming increasingly obvious that the plantation coconut industry in the Territory is due to suffer a considerable decline in production, unless further plantings are made in the next few years by both European planters and Native communities. Many plantations are composed entirely, or in part, of aged palms which are beginning to show senility. Many planters are showing their awareness of this problem and are taking or planning steps to plant new areas.

These talks aim to give some guide in these activities.

Selection of Coconut Seed.—

As with all crops careful selection of the seed to be used is of the utmost importance in making a commercial planting of coconuts. Costs of planting up and copra production costs are at such levels to-day, that the planter cannot afford to neglect any steps which will lead to the highest possible yields from new plantings and he certainly cannot afford the luxury of planting haphazardly-collected seed nuts. Areas of palms from unselected seed nuts are most variable and easily distinguished from an area derived from well-selected seed nuts. In many of the older plantations in the Territory to-day numerous palms can be seen which can be contributing little to the revenue of the plantation while occupying space and taking up their share of maintenance costs and causing higher costs of production. As all planters know there are numerous types and varieties of the coconut palm, many of which are represented in the Territory. To name a few, there are :—

The characteristic tall-palm, the dominant feature in all plantings in the Territory;

The king coconut, with its very attractive appearance, large, heavily laden pendulous fruiting branches carrying golden-orange nuts, and usually early maturing;

Dwarf types usually distinguished by early maturity and rather short life. In this group can be found types bearing all sizes of nuts from very small to quite large and varying in colour through reds, yellows and greenish-brown;

Miniature palms, usually very early maturing, very short lived and bearing a profusion of tiny fruit;

Drinking types usually of the tall-palm group but bearing distinctive bright yellow fruit either perfectly rounded or wedge-shaped. These have very palatable milk but are useless for copra production.

There are many other types not so commonly known in this Territory. To mention one which shows the versatility of the species there is the Macupuna nut of the Philippines which has albuminous milk in every three out of four coconuts approximately, also the local coconut, which is especially liked.

To the commercial planter in the Western Islands of New Guinea most of these types, with the exception of the typical tall palm, are of mainly academic interest. They are certainly of interest to the plant-breeder who in a long-term programme contemplates incorporating some of their desirable characteristics in a new variety but to date, generally speaking, no other has been found to surpass the tall-palm as an all-round producer for copra manufacture. Quite apart from questions of yield, longevity and quality, many of the other types give unsatisfactory leathery, or soapy, copra. Selected dwarf types attracted considerable interest during the last thirty years both in Malay, Ceylon and Fiji and commercial plantings were made; however, generally speaking, these types have not always lived up to expectations and commercial interest in them is said to be waning. However, one Company here has done considerable replanting recently with quick maturing coconut palms on the advice of a Plantation Director from Malaya.

Various practices are followed in selecting coconut seed nuts for planting. For instance seed nuts may be taken in bulk from a block of palms which are known to be high-yielding from accurate records and on inspection are very uniform in appearance. Ideally, however, seed should be taken from marked individual mother-palms and particularly which have been matched for yield and type for some years, if possible. In this Territory, as has been pointed out already, so many of our existing stands are far from uniform. Nuts from these individually selected coconut palms can be expected to give anything from a ten per cent. to twenty per cent. higher yield on the same soil than a plantation planted with unselected nuts.

Mother-Palm Selection.—

Various characteristics should be sought in selecting mother-palms for seed production. In selecting it is desirable to choose palms at least twenty years old and not more than fifty years old. However, selections from young, early maturing and heavy yielding palms is definitely much preferable to no selection at all, especially if they are derived from selected nuts in the first instance.

First the general appearance—Palms with unduly thickened or unusually slender trunks or with poor bole development should be avoided. Careful attention should be given to the type of crown which should be well rounded and well filled in. Palms with fan-shaped or gappy crowns should be avoided. Leaf shape should also be taken into account. The fronds should be of good length and give the appearance of suppleness. Spiky or sharply-tapering leaves rule out a palm. Finally, all palms showing abnormalities such as distortion of the trunk, or twisting of the leaves, should be discarded.

Secondly—yield. Both the numerical yield of nuts and the yield of copra from individual nuts has to be taken into account. Good palms growing under good conditions in the Territory should yield an average of 40 to 50 nuts, but selected areas and palms can yield about 100 nuts averaging 6-8 ounces of copra each per annum. It can be seen that yield recording will be necessary if mother-palms are to be accurately selected. However, experienced men can very often pick high-yielding palms by visual observation, particularly if palms have been under observation over a period of several years.

Thirdly, the characteristics of the individual nut—the desirable copra nut has a relatively thin husk and a large kernel with thick meat. The main consideration is because there is a very high correlation between the weight of a nut and its yield of copra.

For the mathematically minded; the correlation between the weight of a husked nut and the weight of copra is .9, and between an unhusked nut and the weight of copra approximately .6 where unity is complete correlation. Hence the chances are that a well-shaped, heavy nut, even if weighed in the hand, is a heavy yielder with good potential.

In practice it is found that these characteristics in coconuts are usually closely related to the shape of the unhusked nuts. The coconuts which are most consistently desirable are of medium size and rather rounded or dumpy in appearance being noticeably flattened at the tip end. The kernel is even more definitely flattened in appearance, being quite shallow from stalk end to tip end, but having a wide diameter in horizontal cross section.

Pear and wedged shaped, oblong and too eliptical are commonly poor copra yielders. It is to be hoped that very large nuts should be treated with suspicion except where they are from proved types such as the San Ramon and Markham nuts, both of which are available in this Territory. Such oversized nuts are usually borne in small numbers and have other undesirable characters such as very thick husks and small kernels.

Selection of Areas to be Planted.—

Careful attention to the selection of sites for plantings will be possibly the most important factor determining commercial success or failure of a coconut planting. We are indeed fortunate in the Territory in that coconut plantings are so widely distributed around the coasts and located in such a variety of environments, ranging from the low to the high rainfall zones and over a wide variety of soil types. In most Districts there are sufficient plantings to give a clear indication as to the future. It is the work of the Department of Agriculture to catalogue and document this infor-

mation, and to determine the causes of success, or failure, under various conditions so that precise recommendation can be made in future years. This work will, however, take time as will proper soil surveys and in the meantime planters will be well repaid by carefully observing the results of past plantings and applying the information in selecting new areas.

Various soil types with a definite history of coconut failure should be avoided. There have been some suggestions that such areas can be used if fertilizing, or other cultural practices are employed. However, it must be realized that the areas in other countries, like Ceylon, where the application of fertilizers brings about increase in yield, have already been selected and planted as good coconut land. The mere fact that fertilizing has a beneficial effect on palms in any particular area is not in itself sufficient to recommend the practice. The real question is will the increased returns from fertilizing pay for the cost and leave a profit margin over, or in other words, will it consistently, over a period of years, put money in the planters' pockets. Having in mind the cost of importing fertilizers to the coconut areas of the country, it seems to us to be unlikely in the case of the poorer soils but well worth experimentation with while prices are high, as it has paid handsomely in Eastern plantations under selected conditions.

Areas or soil types with a definite history of coconut failures should be avoided. This Department does not hold out hopes to planters that such country can be economically brought into use by the application of fertilizers or by particular cultivation practices and feels that effort should not be wasted on it when there is so much good land available. Some of the types of country which have given poor results in the past are—

Heavy clay soils which are invariably unsuitable for coconuts;

Steep and sloping land other than in areas of particularly high fertility;

Red soils, particularly red clays associated with coastal limestone formations where the soils are too shallow;

Gravelly, or rubble soils, and soils with gravel or rubble strata at various depths.

Sour or acid sands, usually distinguished by a marked development of fern growth and the failure of leguminous cover crop to establish.

Rural Broadcasts :

II.—SOIL TYPES, OTHER FACTORS AND SELECTIVE PLANTINGS

IN the previous talk in this series we stressed the value of careful attention to coconut seed selection, new plantings or replanting and described the process of selection. At the close of the talk we had begun to discuss the selection of planting sites and the suitable soil types and had stated that generally heavy clay soils, steep and sloping land, red soils, particularly red clays, gravelly or rubble soils and sour and acid sands were unsuitable for coconuts.

Soils Suitable for Coconuts.—

Generally speaking, the soil requirements of coconuts are for a deep and well-drained soil of at least moderate fertility. Soil moisture conditions are of the utmost importance. Coconuts will tolerate quite sandy soils, provided they have correct sub-surface water conditions. Soils should be free-draining to a great depth for the best results and, therefore, the deeper loams of volcanic deposits are generally the most favoured.

Better types of coconut soils in the Territory are as follows :—

Volcanic Soils.—

These fall into two classes.

Firstly pumices and similar soils such as are found in the Gazelle Peninsula area, New Britain, in parts of Bougainville and north coast of Papua, around Collingwood Bay and the Soputa-Dobadura-Sangara area and on the south-east coast of Papua in patches. These soils are very light, free and porous and are of high fertility. They generally provide excellent conditions for coconut cultivation except in cases where subsurface bands of lava interfere with drainage as occurs in part of the area associated with Mount Lamington.

Secondly the soils formed by weathering of volcanic lavas are found along the north coast of New Britain in the Talasea Sub-district and on islands off the north coast of New Guinea, such as Kar Kar and Manam. The suitability of these soils depends largely on their degree of maturity and depth of weathering. Where fairly matured and deeply weathered these highly fertile soils give excellent conditions for coconuts. However, in some cases over the newer deposits of lava, they are shallow, with a tendency to be puggy close to the surface, or not to retain water well and give less valuable soils.

Alluvial Soils.—

These soils are found associated with major river deposits and once again can be high in fertility and very satisfactory as far as soil moisture conditions and drainage are concerned. Throughout the Territory coconut plantings are found at the mouths of streams on this sort of soil but there has so far been so very little exploitation or testing of alluvials along the inland portions of the major rivers. Unfortunately, owing to the fast-flowing nature, many of our streams and their alluvial deposits are marred by gravel or rubble bands which make them most unsuitable for coconuts.

Old Beach Sands.—

This group can be divided into two important types. Firstly, old beach sands which consist largely of the seaward deposits of river systems largely thrown back by the sea on to marine beaches giving very often a quite satisfactory soil for coconuts. Many valuable plantations along the south coast of Papua are planted on this type of formation. Secondly, beach sands of predominantly coral sand structure which are associated with old reef formations and are to be found in areas such as the western end of New Ireland, and on many coral atolls. These sands have a very variable history as far as the response of coconuts goes, and results with coconuts seem to depend largely on subsurface moisture conditions; where water is free-moving beneath these sands coconuts have done very well. However, where there is locked or stagnant subsurface water, the results have invariably been early mortality.

Coastal Soils with Fissure Coral Formations.—

In many parts of the Territory coconuts have unexpectedly done well on this sort of country, particularly when the shallowness of the soil itself in such areas is taken into consideration. The formation usually consists of a platform of raised coral extending back from the sea with a shallow deposit of soil on top. The soil itself would appear to have no resistance to desiccation but it is thought that the coconut roots are able to penetrate the subsurface coral formation where water is stored.

Other Factors in the Selection of Land for Coconut Plantings.—

Some thought should be given to climate when considering coconut planting and, in particular, rainfall. The distribution of rainfall throughout the year greatly influences its effect on coconuts; however, under normal tropical conditions of alternate dry and wet seasons rainfalls should not be below 65 inches and preferably not higher than 150 inches and areas with excessively long dry seasons, e.g. seven and eight months, should be avoided. Some of the dryer areas have land suitable for coconuts by reason of good subsurface moisture conditions, influenced by rivers or underground water. Some areas have a definite history of recurrent drought with damaging effects on crop yield and particularly where the soils are shallow or heavy such areas should be avoided. Generally the very wet areas do not give the best results with coconuts and there are other undesirable features for commercial copra production such as difficulties in the drying and storage of copra.

Altitude is also a factor to be considered and generally speaking areas with altitudes greater than 500 feet should not be considered although it is to be noted that coconuts do very well in certain localities which are very fertile, such as the pumice belt of New Britain at an elevation of 1,000 feet or more.

Selective Planting of Estates.—

Within a good area which has been selected for planting up of coconuts, it will pay the planter to make a careful examination to determine whether all, or part, of the land should be planted. This is particularly so in this Territory where the coastal soil types are extremely variable and even within a reasonably small area, say 1,000 acres, on country generally suitable for coconut planting, it will be found that there are considerable patches of unsuitable land. The natural vegetation is often the best indicator of such poor patches. All land which has stunted vegetation, or otherwise abnormal natural cover, e.g. the predominance of pandanus palm, sago palms, nipa palms or other swamp vegetation should be avoided. Comparatively little observation would serve to familiarize the prospective planter with the general appearance of normal forest cover in any area and enable him to detect abnormalities. Particularly, in the German times (1896-1914) when many of the existing stands in the Territory of New Guinea were planted the plantations were not established by the ultimate occupier, but were planted under contract and large areas of country were simply planted up without any regard for local soil variations. Thus many plantations in that Territory to-day will be found to consist of a portion which is highly productive and another portion which has little or no production. It must pay the modern planter to only plant up those areas which will ultimately give him satisfactory yields. Any money spent in the planting, or early maintenance of unsuitable lands is so much money down the drain.

Soil-water relationships, related to subsoil conditions, are among the main factors affecting healthy coconut production. Undesirable subsoil with rock hard pans, ironstone hard pans, waterlogged due to stiff clay subsoil or swampy conditions, can all lead to conditions of physiological drought or cause real inability for the palm to get sufficient water and nutrients to give full healthy growth. Such shows up in unhealthy conditions in the palm canopy such as taper stem, yellowing or chlorosis; leaf break; leaf droop (i.e. dead leaves hanging around the stem) and can even cause a severe wilt under extreme conditions.

Rural Broadcasts:

III.—COCONUT NURSERY AND PLANTING PRACTICE

IN the two previous talks in this series on coconut planting we discussed the selection of seed coconuts and of land suitable for coconut planting. We pointed out that careful attention to both these phases of establishing a coconut planting would well repay the planters.

In the present talk we intend to discuss the final phases of establishing an area of coconuts, i.e. nursery and field planting methods. As with all other aspects of planting, careful attention and the adoption of correct practices will inevitably repay the planter. The aim is to produce a healthy and vigorous seedling and the benefits to be derived from this are—

Firstly, earlier flowering and fruiting.

Secondly, proper development of the root system, bole and trunk of the young palm giving greater longevity, the capacity for increased yields, and better resistance to adverse factors such as drought.

Thirdly, earlier and more complete filling in of the overhead canopy formed by the crowns of the palms, with resultant benefit in the protection of the soil, and the improvement of maintenance conditions. Many weeds, particularly some of the coarser grasses, such as kunai (*Imperata cylindrica*) are lovers of sunlight and their growth is favoured by plantings showing many misses and where proper replanting was neglected in the early stages.

In selecting a coconut nursery site, a level, well-drained area should be sought. In wet country the site should be well provided with effective drains. Wind protection is important, and if the site has no natural windbreak an artificial wind barrier should be provided. Light overhead shading, using material such as grass or palm leaves, is also desirable.

The selected seed coconuts are placed on their sides in the nursery. They should not be crowded too closely together and every six or so rows a space should be left for a path so that the seedlings can be adequately inspected. In the wetter areas the coconuts will germinate and commence to grow without any further attention, however, under drier conditions watering is necessary to keep up humidity in the nursery, and watering with a can or spray should be resorted to if any dry spell occurs during the raising of seedlings.

The young shoot of the coconut grows out through the husk and first several seedling leaves appear. These are dark green, rather cabbagy in appearance when uncurling and differ from ordinary foliage leaves in being undivided. After three or four seedling leaves emerge, the first foliage leaf appears, having the characteristic strong midrib with narrow leaflets arranged along each side.

Seedlings are ready for planting out when the first foliage leaf has fully opened and the following leaf appears spear-like, in the centre of the young palm. At this stage the seedlings in the nursery should be closely inspected and all those which are unthrifty, yellowed, or show any other abnormalities such as twisting or crumpling of the leaves should be discarded.

Planting holes for coconuts should be dug at least three months before planting takes place and should be spacious to allow for adequate development of the root system of the young seedlings. Minimum recommended dimensions are two feet six inches by two feet six inches by two feet six inches, and it is advisable to increase these in heavy loam or clay soils.

Several layers of coconut husks are placed in the bottom of the hole and the soil is returned in the order in which it was removed. If available, leaf mould should be well mixed in with the soil as it is returned, and if practicable coconut husk ash can also be added. Finally the seedling should be placed centrally in the hole with the shoot erect and the upper surface of the seed nut coming just below the general soil surface, the soil being filled in to leave a shallow dish-shaped depression sloping down to the top of the nut.

Planting on the triangle is generally recommended as making the fullest use of prepared land. On the lighter soils such as pumices, sands and sandy-loam a spacing of twenty-seven feet on the triangle is

recommended, while this should be increased to thirty feet on heavier land. From experience these spacings give the best canopy development under conditions in the Territory. Any planter who is establishing coconuts on fertile, well-drained soils under good rainfall conditions in this Territory should have in mind the possibility of a later interplanting with cocoa. With the spacings quoted, canopy development by the coconuts themselves should be such that there will be little need for any other type of shade in most cases.

Supplying and Replanting.—

The practice of replacing palms which have been lost for some reason or have been cut out on account of faults, by planting new seedlings in the same position as the originals is known as supplying. It is properly used to fill in gaps in developing plantations. Supplying should generally not be practised in mature or ageing stands of coconuts. There are exceptions, e.g. where large areas have been lost through lightning strike or fires or war damage. The soil in the immediate vicinity of a palm which has been bearing for thirty to fifty years is at least temporarily exhausted, while supply plantings among aged coconuts will barely have begun to yield when the surrounding stand becomes unproductive.

The correct procedure with ageing coconut stands is to replant them, providing always that there are adequate indications that the soil is sufficiently good to support replanting. In replanting the nursery the planting procedure already described is followed and the new seedlings when planted out are placed at the maximum possible distance from the trees of the old planting. Large holes with plenty of consolidated top soil filled in and consolidated before final planting is recommended. Thus in triangle planting each new seedling will be at the centre of a triangle of three of the old palms and the rows of new seedlings will run centrally between those of old palms. The replants are allowed to develop until they commence flowering and the old palms are then cut out.

N.B.—This Broadcast on Coconuts necessarily leaves out a lot of valuable data due to the radio time available. It is expected that more detailed articles in this *Journal* will be probable from time to time dealing more specifically and deeply with the individual subjects on coconut culture.

Printed and published by William Samuel Nicholas, Government Printer, Port Moresby.—6717/3.55.